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Application of a synalysis packaging design method in PC magniviewer package redesign

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APPLICATION OF A SYNALYSIS PACKAGING DESIGN METHOD IN PC MAGNIVIEWER PACKAGE REDESIGN

BY

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for the thesis requirements for the
Master of Science Degree.

Richard Stryker

Dan Goodwin

August 2002

Title of Thesis: Application of a SyNalysis Packaging Design Method in PC MagniViewer Package Redesign.

Date: August 2002

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Finally, my thanks also go to Sam and Art, my two sons, and to my mother for their help and cooperation so that I could find time to work on this thesis. I hope that sometime, when my sons grow up, they can benefit from it.

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ABSTRACT

This study addresses the over-packaging phenomena in packaging design perspectives and, through the review of architectural design methods and packaging design principles, sets up a SyNalysis packaging design method with the packaging design process. Furthermore, an example of a PC magnifier redesigning is demonstrated in the thesis, step by step.
The SyNalysis method contains scientific analytical methods and the designer's creative, synthetic methods. Its embodiment is presented in three processes: analysis, design and evaluation of the processes.

The SyNalysis packaging design method serves as a guide to help packaging designers, and especially new and inexperienced designers pursue a more logical and practical way to create a better design. In addition, this packaging design method can also help packaging science students master packaging design skills in a more efficient way.

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1.0 INTRODUCTION

In any design process, when one faces a task of designing the package for a product or renovating an existing packaging design, there are always questions like how and where to get started in the design. How can one avoid designing an over-packed or under-packed package? How would one analyze the old design and use the information in the redesigning process? One has to consider many factors, go through many steps, and sometimes use creative approaches in order to come up with a solid packaging design. Traditionally, each packaging designer has his/her own way in applying packaging design theory to the real design problems, which can result in inconsistency in product packaging in terms of performance and cost effectiveness. It would be beneficial to the packaging design community if there were some type of practical and logical method to guide designers in their design procedure. A review of the packaging design literature shows a lack of such methods, although some writers call for a practical method.

The goal of this thesis is to set up a practical packaging design method by reviewing packaging design principles and comparing them with architectural design methods. To illustrate the application of such a method, PC MagniViewer packaging redesign is used as an example, showing the practical packaging design process step by step. The main idea of the thesis was triggered by a project to generate new specifications for a PC MagniViewer for a large optical goods corporation. The apparent over packaging of the old design raised questions about design methodology. Why did the previous designer do it this way? Was it because of a lack of designing skill or simply a wrong approach? How would it be helpful if a practical but logical design method were used for guidance?

This study is limited to consideration of packaging structural design. Graphic design for presentation of information about the product is not included in the development of this topic.

2.0 PROBLEM AND ITS SETTING

2.1 Background

The concept of packaging can be traced back to the beginning of human history. When humans became hunter-gatherers, they used natural materials to fabricate objects to contain, protect, and transport food, medicines, clothing, ornaments, and other items. The "shoppers" of the day used hollow gourds, tree bark, and animal bladders. Through out the packaging history, there have been several stages of packaging development:

- Direct Natural Packaging: People use natural resource like plants, leaves, animal skin or bladders, and shells as packaging materials to wrap, fold, contain or simply cover things.
- Hand-made Craft Packaging: People use plant fibers to braid bags, baskets, and boxes or used other materials like wood and rock to carve containers.
- Ceramic Container Packaging: The invention of ceramic marked the beginning of human civilization. Ceramic containers were used as food packaging and they continue to be used now.
- Bronze Age Packaging: With the discovery and refining technology of bronze, the bronze container developed. The durability and the toughness of the bronze container were big improvements compared with the ceramic container. However, due to its stiffness, it was hard to form certain shapes, so it died out early.
- Iron Packaging: Iron containers were usually large and heavy compared to the bronze container because ancient people were not able to make thin iron sheets.
- Paper Packaging: Paper was first used as lining and cushioning materials in packaging. Then it was used as a container with the development of technology. And people have been using it constantly in packaging today because it is light, cheap, and easy to form and dispose.

Early package design started at the hand-made craft package stage. At that time, the design grew from human natural instinct, and the process was simple. With the evolution of human history, design became increasingly complicated. The development of new technology and the change of people's lifestyles have greatly influenced the way package design is conducted. For example, the invention of paper enabled design-by-drawings styles for most package designs. Nowadays, the components of package design are not limited to form and art design, but also include many materials sciences, mechanical technologies, and manufacturing processes, as well as market and cost. A packaging engineer is responsible for understanding all elements and their interrelationships involved in the complicated package design process. Obviously, this is by no means an easy job. Unfortunately, over-packaging of products is common to companies everywhere and the reason for over-packaging may be the lack of the necessary packaging design knowledge or the know-how of handling the complicated relationships across all elements encountered during package design. In these cases, designers tend to be on the safe side by over-packing products, which is not a good solution in terms of overall cost, the complexity of manufacturing and environmental responsibility for wasted materials. Moreover, such packaging may not necessarily be more protective for the product.

Today, with the rapid development of technology and intense competition in industry, over-packaging is no longer an acceptable solution. Many major companies have launched some form of innovative cost reduction programs in packaging engineering. I hope that the design methodology presented in this discussion may provide a useful tool for efficient packaging design.

2.2 The Need to Have a Practical Design Method

Packaging performs essential roles in the protection, containment, and identification of the product. These basic tasks must be carried out at the reasonable cost with a minimum impact on the environment.

- Protection: Protection is the goal of the packaging. Protection methods vary with the characteristics of the products and consumers' needs.
- Containment: Containment is the means through which packaging reaches its goal. It is presented by a three dimensional form to locate the product.
- Identification: Identification of the product consists of a description of the contents. In most instances, there is information about the product and its use, or a legally required text. The identification role may be extended to include promotion, where the package not only identifies the contents, but also actively promotes them. The primary use of graphics is to establish product identity.

Packaging engineering is a set of systematic, integrated activities, which means that packaging design cannot be conducted in isolation. While creative thinking is important during packaging design, the success of a good packaging design depends more on analytical, synthetic skill and design disciplines. This is because many requirements besides basic packaging functions will also impact the packaging design. Examples of these requirements are economy, regulation, environment and aesthetics (in consumer packaging design). It is not easy to deal with all these factors at the same time during the design. Only having the theory and principles is not enough to master the complicated design process, even for experienced designers, so it would be quite helpful to have a practical and efficient design method to guide the design, step by step.

3.0 COMPARISON OF ARCHITECTURE AND PACKAGING SCIENCE

3.1 Reasons

Among design activities, few of them create space to contain an object. This is the major objective of both building design and packaging design. Building design creates a relative large space for its intended objects, human beings, so does package design with smaller space for its objects-- various forms of products. The following table lists some comparable elements for both architectural design and packaging from a design perspective.

3.2 Comparison

Table 1: Comparison of Packaging and Architectural Design

Elements	Packaging	Architecture
Space	Package	Building
Object	Product	Human being
System	Distribution flow	Activity flow
Integrate	Tertiary	Total Site
Individual	Secondary	Single building
Part	Primary	Room
Detail	Components	Detail
Technique	Production	Construction
Test	Lab or road test	Check by person
Life time	Short period	Long term
Cost	The least cost	Depends on budget
Environment	Recycle, reuse, returnable at the least disposal	Rational layout, coordinating with environment,

3.3 Findings

From the comparison of architecture and packaging science, we can see that there are many similarities in both design prospects.

- **Design goals are similar**
  They both create spaces, even both design objectives and the results are very different.
- **Design principles are similar**
  Neither of them are pure artistic design, but functional design. In packaging design, form submitting function is a mainstream for majority of designs and function submitting form cases are only appeared in consumer product for marketing or exhibiting reasons.
- **Thinking methods are similar**
  They both have to balance function, structure, aesthetics, economics, materials, and construction and production factors as well as deal with environmental issues; even their contents are quite different.

Both require logical, analytical and synthesizing thinking skill to deal with all the factors well.

- **Working styles are similar**
  They both have cross-functional working style that demands people from different functioning areas to work together. The effectiveness of cross-functional teams directly affects the quality of the design.

Since architectural design and package design processes have similar design goals, design principles, thinking methods as well as working styles, we think it is logical that we can apply some of proven and practical design methods in building design process to the packaging design field. We feel this will improve and ease the current design workflow in packaging engineering.

4.0 REVIEW OF ARCHITECTURAL DESIGN METHOD AND ITS PROCESS

There are four main elements in architectural design: function, form, aesthetics and economy. While there are still arguments between form submitting function and function submitting form today, the mainstream of architecture design is form submitting function even there do existed cases of function submitting form. The Sydney Opera House in Australia is an example of function submitting form. Even though it was costly and difficult to construct, it has been well known as a piece of excellent work by its fascinating sail sculpture in the harbor. However, regardless whether you start your design from form submitting function or function submitting form, the form definitely has to match the function at the end. Architectural design is a very complicated and difficult process. There are many factors to be considered and numerous problems to be solved during the design process through analysis, synthesis, comparisons, compromise, etc. Generally, we profile the design process into three main processes, they are:

4.1 Exploring and Investigating Process

Before starting the design, exploring the site where the new building will stand on is essential. We need to collect information of climate; directions; geographical condition; surrounding environmental condition and existing aesthetic style status for the consideration and limitation of the design. In same time, collecting the user's needs and client's requirements are indispensable. Investigating the existing similar building's advantages and disadvantages as well as the material market are important too.

4.2 Creative Process

Creative process penetrates through the whole design circle from beginning to end. This is because each component in the design circle requires creative agents. Creative process will not end until the design completes. In brief, the creative process is **Problem... Definition...Attempt solution...Incubate...Inspiration...Elaboration/Completion**[*].

4.3 Design Process and Design Procedure

In building design process, all elements are classified in two categories. One is "known" elements, such as the base knowledge of building design, the area of the site, location, climate, client requirements, budget, legal requirements, etc; the other is "unknown" elements that need to research or create. They are tools, visualization, plans, sections and elevations, sketching and modeling[1].

The building design process is as simple as **known...unknown...return known**[1]. It means all known elements are programmed based on knowledge at hand, research those unknown elements through acquiring new knowledge about them, convert the unknown elements into new known ones, and finally, solve conflicts if any between new known elements and already known ones.

Integrate...Individual...Parts...Details...Individual...Integrate:

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[1] Design Process: Primer for Architectural and Interior Design by Sam F. Miller 1995

This is a very important step-by-step design procedure. Integrate means the whole set of design activity flow that covers the whole buildings and its site design. Individual is a set of design activity covering a single building or a set of union. Part is a set of design activity for a single room; details are all components to be designed or considered from inside to outside of the building. Completion of detail design does not signify the end of building design process, you have to return from details to parts to make sure that there is no conflicts at all, otherwise, you have to solve them by revising the details design or individual design. Similar step applies when you finished parts design and return to the individual building design. Once a "perfect" single building is finished, it is time to go back to integrate design using the method as above to check, solve and revise if necessary. It is a very useful and revisable design procedure to follow during a long and complicated period of design. Designers will not easily get lost in their design work when this procedure is applied.

4.4 Revising Process

The purpose of this process is to connect and assure the integrity of each design stage by measuring whether or not the design meets all requirements that we set forth at the beginning of the design. Notice that this is repeatable process. The designer constantly reviews the design against the requirements to see if further revising is needed.

In general, researching and programming, designing and drawing, checking and revising plus creative agents constitute the completely building design process.
Integrate...Individual...Part...Details...Individual...Integrate is a practical and useful building design procedure from which we will set up a practical design method for package design.

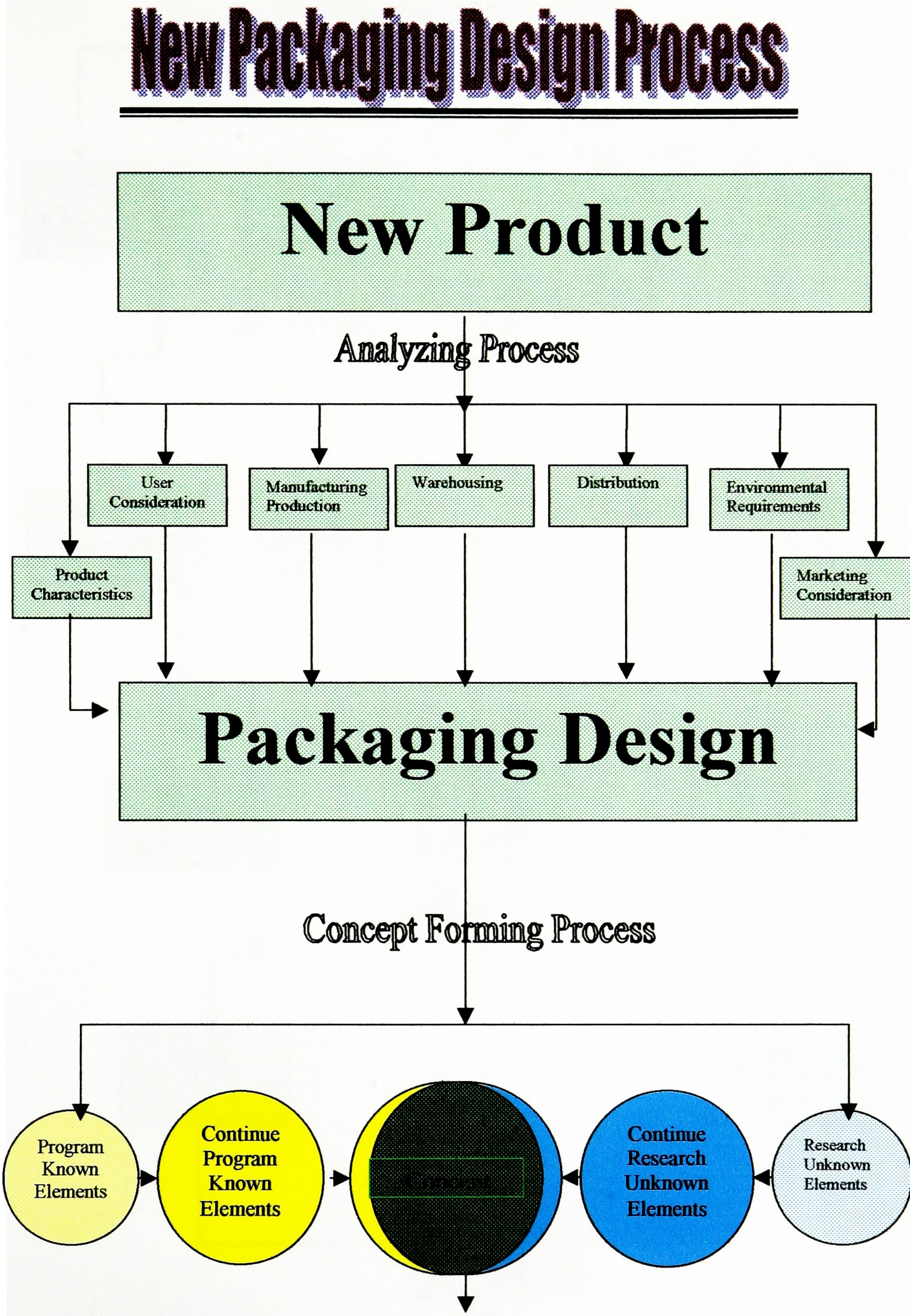
5.0 ESTABLISHING A SYNALYSIS PACKAGING DESIGN METHOD

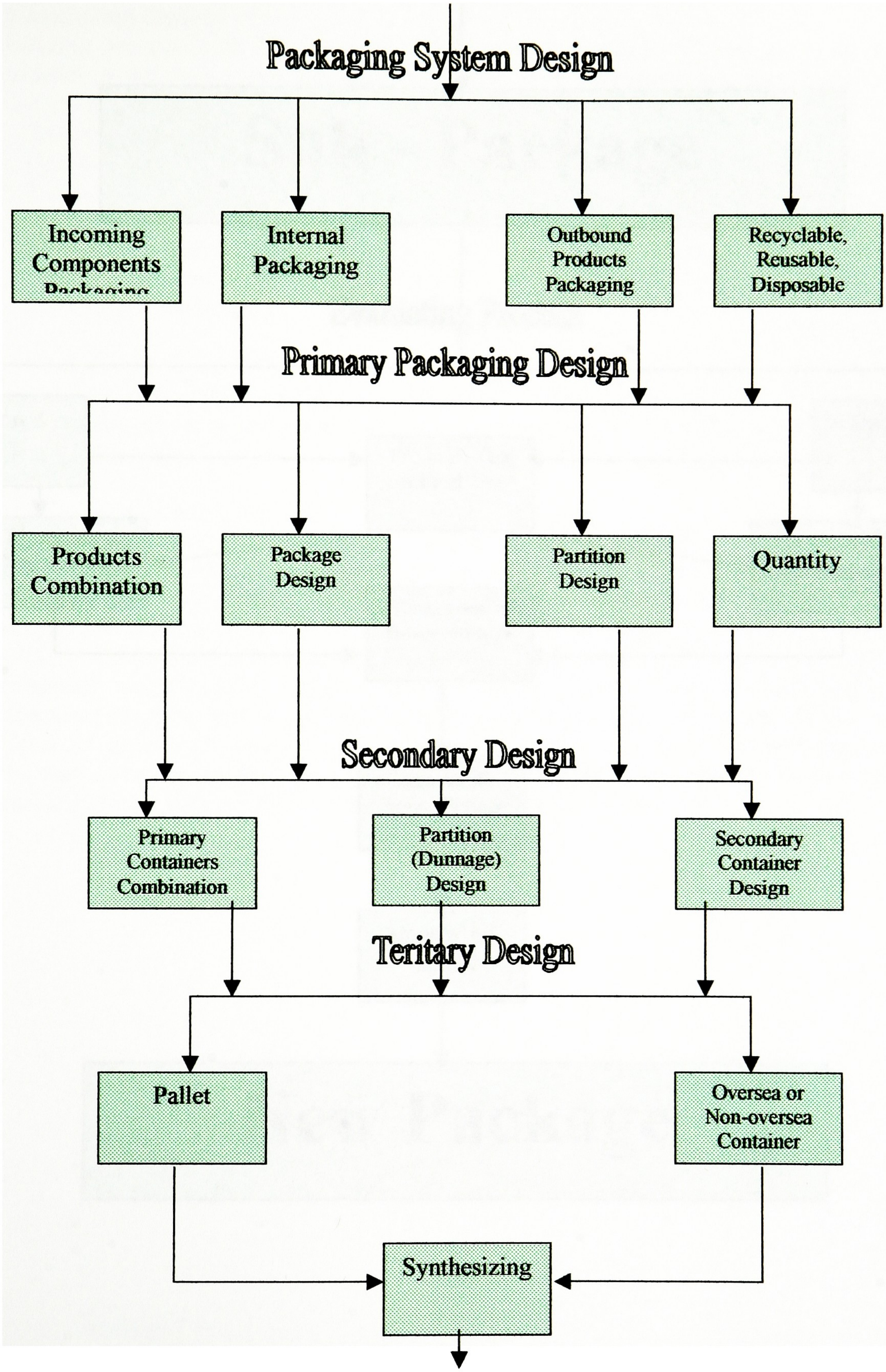
Before setting up the practical packaging design method, let us review the definition of the design method. What are design methods? In a sense, any identifiable way of working, within the context of designing, can be a design method. In other words, design methods are any procedures, techniques, aids, or tools used in designing. Method is a general name, and its core lies on the process the method embodies.
Packaging design is just like building design that creates a space. Package design is not only a creative process but also a process that requires both analyzing and synthesizing activities because it is a combined process of design and science. Usually, for design, synthesizing is a dominant method while for science, analyzing is the major tool. Therefore, packaging design should consist of both analyzing and synthesizing methods. SyNalysis, an acronym is used to denote a practical packaging design method. SyNalysis means a process of combining both analytical and synthetic activities with creative effort. In reality, a *package* is a product of analysis and synthesis process and *packaging* is a complete system resulting from a series of analysis and synthesis.

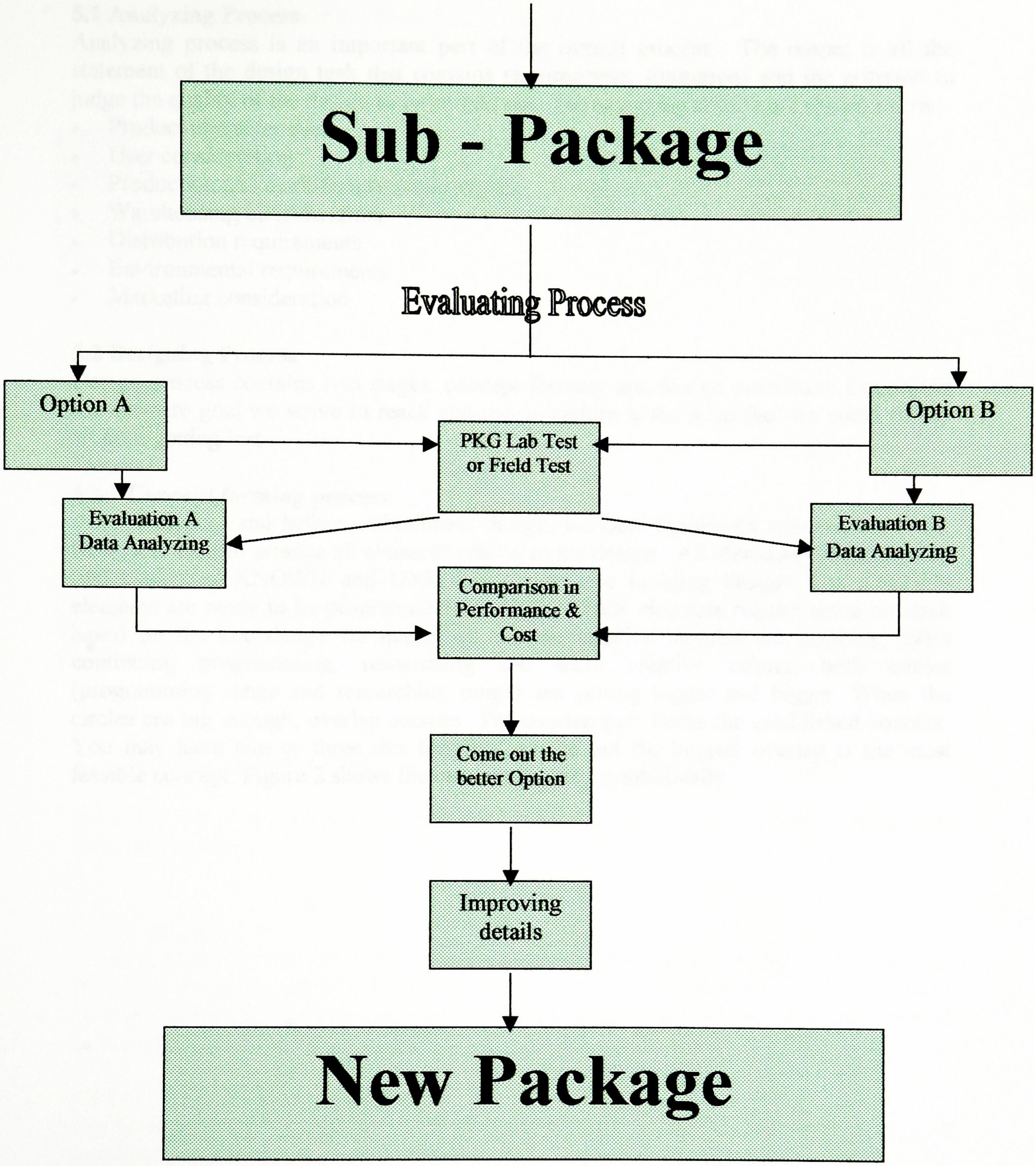
SyNalysis packaging design method will allow information to be collected rationally, and to be incorporated systematically into the design process. Specifically, SyNalysis is also a practical process, its **integrate...individual...parts...details...individual...integrate** design procedure allows packaging professionals to stay on the right track during the design by providing a straight forward and step by step guidance to the complicated packaging design process.

SyNalysis packaging design method consists of three processes (See Fig. 1 below) they are 1) Analyzing process 2) Design process 3) Evaluating process and it also contains a creative concept forming process as well as a design procedure.

Figure 1:


New Packaging Design Process
New Product
Analyzing Process
User Consideration
Manufacturing Production
Warehousing
Distribution
Environmental Requirements
Product Characteristics
Marketing Consideration
Packaging Design
Concept Forming Process
Program Known Elements
Continue Program Known Elements
Continue Research Unknown Elements
Research Unknown Elements


Packaging System Design
Incoming Components Packaging
Internal Packaging
Outbound Products Packaging
Recyclable, Reusable, Disposable
Primary Packaging Design
Products Combination
Package Design
Partition Design
Quantity
Secondary Design
Primary Containers Combination
Partition (Dunnage) Design
Secondary Container Design
Teritary Design
Pallet
Oversea or Non-oversea Container
Synthesizing


Sub - Package
Evaluating Process
Option A
Option B
PKG Lab Test or Field Test
Evaluation A Data Analyzing
Evaluation B Data Analyzing
Comparison in Performance & Cost
Come out the better Option
Improving details
New Package

5.1 Analyzing Process

Analyzing process is an important part of the overall process. The output is all the statement of the design task that contains requirements, limitations and the criterion to judge the quality of the design to be carried out. The analyzing criteria are shown below:

- Product characteristics
- User consideration
- Production and manufacture requirements
- Warehousing considerations
- Distribution requirements
- Environmental requirements
- Marketing consideration

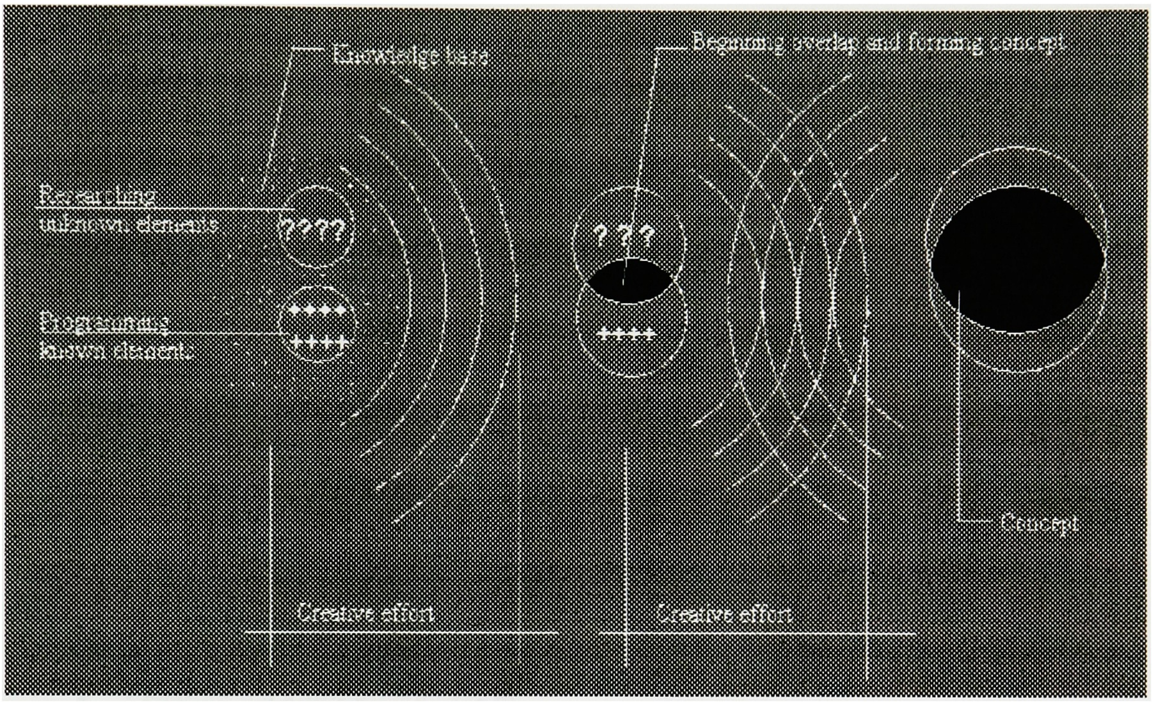
5.2 Designing Process

Design process contains two stages, concept forming and design procedure. Concept is the ultimate goal we strive to reach and the procedure is the steps that we could fellow without getting lost.

5.2.1 Concept forming process

After analyzing and before embodiment design, we have the design statement in hand. Now, it is time to arrange all elements related to the design. All elements can be divided two categories KNOWN and UNKNOWN just like building design. The KNOWN elements are ready to be programmed and UNKNOWN elements require some research based on the knowledge we mastering and the creative impulse we inspiring. With continuing programming, researching and more creative efforts, both circles (programming range and researching range) are getting bigger and bigger. When the circles are big enough, overlap accrues. The overlap part forms the established concept. You may have two or three this forming process but the biggest overlap is the most feasible concept. Figure 2 shows the concept forming symbolically.

Figure 2: Concept Forming Process[2]



5.2.2 Design Procedure (integrate… individual… parts & details…integrate)

It is a very practical, useful and step by step procedure that guides designers in a straight, efficient manner.

5.2.2.1 Integrate

Integrate here refers to the whole packaging system from manufacturing to distribution; from warehouse to market; from user to environment. Sometimes, it also includes incoming components. It may include the existed packaging facilities, or creating any of them as new components.

5.2.2.1.1 Packaging System Design

The packaging system design include of the whole packaging life cycle that consists of incoming components packaging from suppliers; internal packaging in production line and outbound product packaging in distribution and warehousing; as well as in marketing and end users. In addition, the recycle reuse and dispose packages are the factors to make

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[2] The figure is partially from Design Process: A Primer for Architectural and Interior Design by Sam F. Miller 1995.

the packaging life cycle long or short in packaging system. Meeting all requirements in the system and the least cost are the main factors and they will be checked up all the time during the whole design process.

5.2.2.2 Individual

Individual design includes every single channel in packaging system, such as production mechanical design, warehouse store method, distribution method as well as environment consideration. Of cause, package design is the main part design for packaging designer.

In package design, Individual also means single package design such as a primary package design, a secondary package design and a tertiary design.

5.2.2.2.1 Primary packaging design

Primary packaging design consists of product combination; primary package design; partition or dunnage design and the quantity of the product in a primary package.

What is worth to mention here before a primary packaging design is the combination of products, which is for the product, contain more than two parts because product's combination affects the primary package's form and its configuration directly.

The good Combination of Products (for more than two parts product) criteria listed as:

- Symmetric & balanceable
- The simplest configuration
- The least dimensions

The good primary package considerations:

- Type of package
- Packaging material selection
- Feasible packaging production
- Environment consideration
- The simplest configuration
- The least dimensions
- The least cost

5.2.2.2.2 Secondary packaging design:

Secondary design consists of primary container's combination and partition or dunnage design and secondary container design.

The good combination criteria of primary package units are similar to the criteria of product's combination. The considerations of secondary packaging design are:

- The best combination of primary package units
- Type of package
- Material's selection
- The best fit pallet and warehouse facilities
- Environment consideration
- The simplest configuration
- The least dimensions
- The least cost

5.2.2.2.3 Tertiary design:

Tertiary design consists of pallet design and oversea or non-oversea container's design. The consideration should be:

- The best combination of secondary package units
- Type of enhanced protection

- The best fit environment, transportation and warehouse

5.2.2.3 Parts and details

Part design and detail design refer to very specifically designs such as the calculation of mechanical protection, and no conflicts between parts etc.

Completing the part and detail design means that the first step draft design has finished. However, it does not mean the whole design process has finished; the important reverse checking and revising steps just follow up.

5.2.2.4 Individual and Integrate

These two steps are reverse checking steps. We need bring these parts designs and detail designs back to individual packages checking up that there are no any conflicts among primary, secondary and tertiary packaging. Then checking up every package is complied with every chain through the packaging system. Make sure everything meets the requirements and there is no conflict at all.

5.3 Evaluating Process

The Evaluating is mostly done through lab test or tour test. In option, you may have two or three design prototypes, test and compare them with the criteria listed below. Then we return to the analyzing process to check against the requirements list, choose the optimum design as the final package. The criteria of evaluating package are listed below:

5.3.1 Function:

To maintain product quality
To meet customer needs
To meet production and packaging line requirements
To communicate well
To promote sell
To confirm with legal and regulation aspects

5.3.2 Structure:

The simplest configuration
The minimum cushion
The smallest dimension

5.3.3 Economy:

Minimum packaging cost

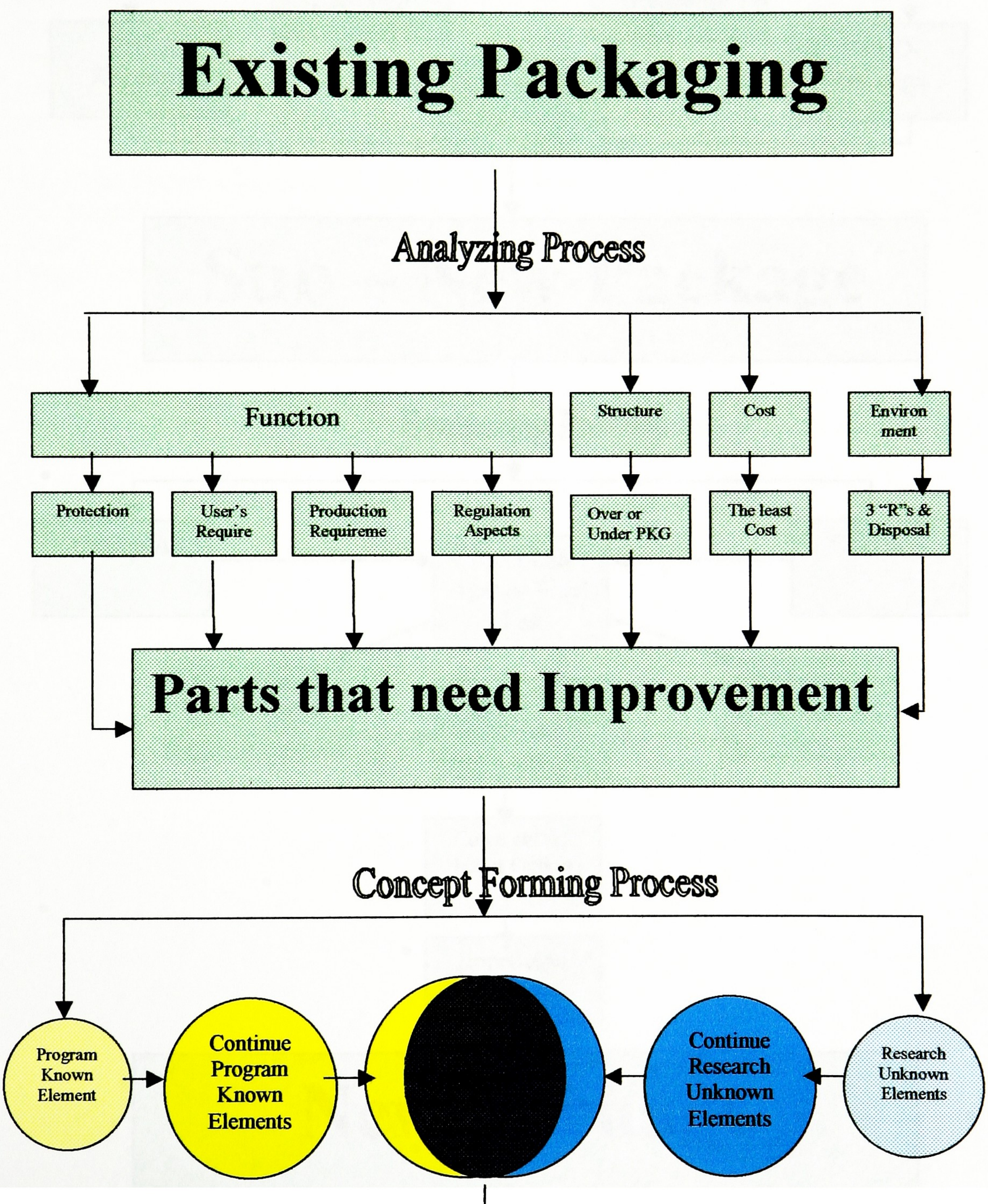
5.3.4 Environment:

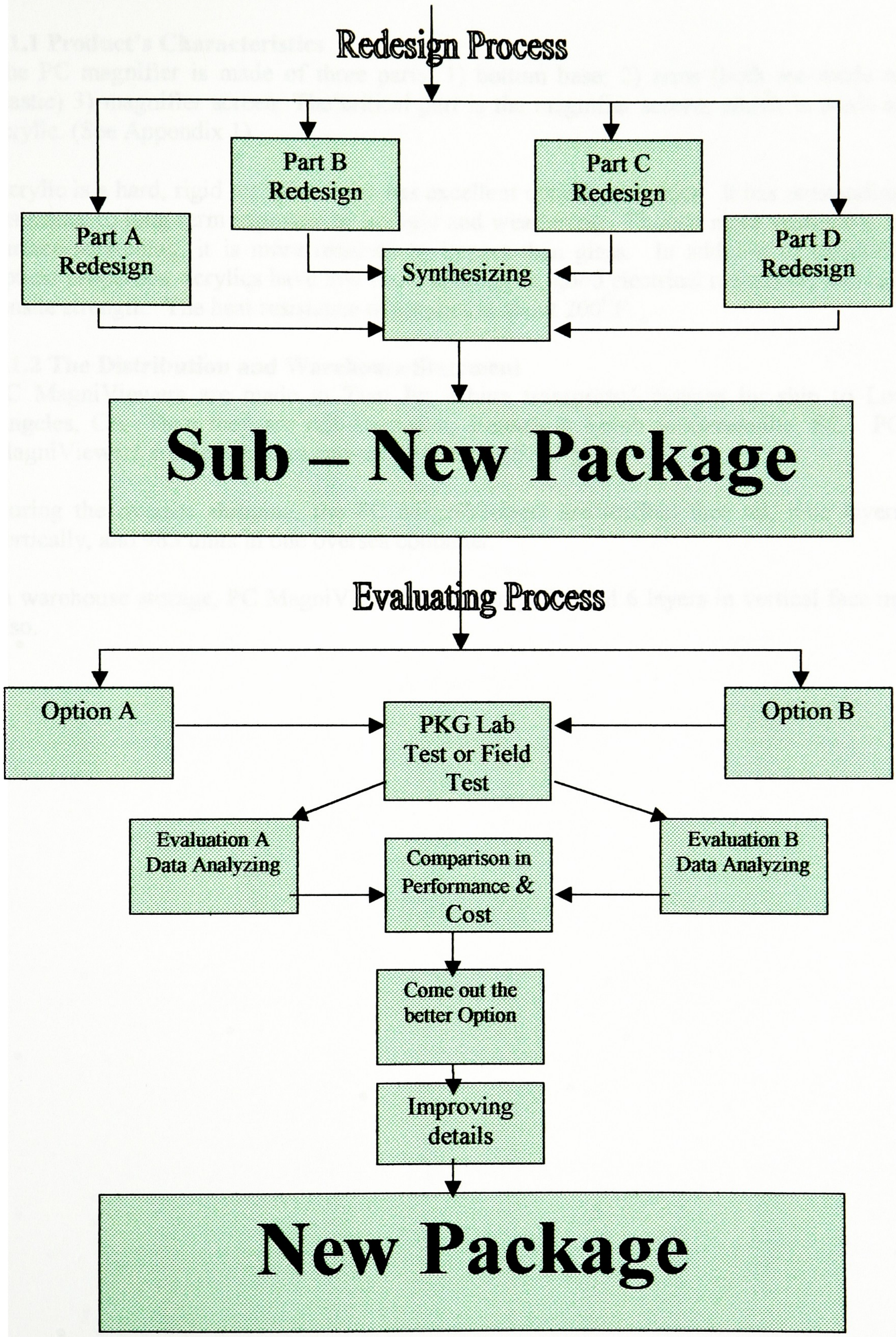
Return, Reuse, Recycle, and Minimize disposal

6.0 REDESIGN THE PC MAGNIFIER PACKAGE WITH NEW METHOD

Redesigning a packaging process is slightly different from a new packaging design process, because redesigning is based on the existing package. Its main goal is solving the existing problems and improving overall package quality, or saving packaging costs. The focus is to find out the critical parts that need improvement through the analyzing process. After identifying all major ***known*** and ***unknown*** elements, one conducts some research for ***unknown*** elements and reprograms all ***known*** elements. Then, one enters the stage of forming the redesign concept and moving on just as the steps used in the new packaging design process. (See Fig. 3 below)

Figure 3: Redesign Packaging Process




Redesign Process
Part B Redesign
Part C Redesign
Part A Redesign
Synthesizing
Part D Redesign
Sub – New Package
Evaluating Process
Option A
PKG Lab Test or Field Test
Option B
Evaluation A Data Analyzing
Comparison in Performance & Cost
Evaluation B Data Analyzing
Come out the better Option
Improving details
New Package

6.1 Analyzing Process

6.1.1 Product's Characteristics

The PC magnifier is made of three parts: 1) bottom base; 2) arms (both are made of plastic) 3) magnifier screen. The critical part is the magnifier screen, which is made of acrylic. (See Appendix 1)

Acrylic is a hard, rigid material and it has excellent optical properties. It has outstanding resistance to long-term exposure to sunlight and weathering. Though more vulnerable to surface scratching, it is more resistant to impact than glass. In addition to excellent optical properties, acrylics have low water absorption, good electrical resistance, and fair tensile strength. The heat resistance of acrylics is about 200^{O}F.

6.1.2 The Distribution and Warehouse Statement

PC MagniViewers are made in Tian Jin, China transported oversea by ship to Los Angeles, CA. Then they are rail-shipped to Bausch & Lomb in Greenville, SC. PC MagniViewers are delivered to end-user by truck. (See Fig. 4).

During the oversea shipping, the PC MagniViewers are stacked face up, nine layers vertically, and 985 units in one oversea container.

In warehouse storage, PC MagniViewers stack on pallet and 6 layers in vertical face up also.

Fig. 4 PC Magnifier Distribution Flowchart

Production Line
↓
Pallets
Fork Truck
↓
Manufacturing
Warehouse
↓
Lorry (truck)
↓
Port Warehouse
↓
Ship
↓
L. A. City Port
↓
Train
↓
B&L Warehouse
↓
Truck or Aircraft
↓
End User

6.1.3 Profile and Analysis

Using the packaging criteria to evaluate the original PC magnifier' package (see Table. 2 below)

Table 2: PC MagniViewer profile and analysis

Criteria / Packaging Components	Functions	Structure	Cost Each/RMB	Environ-ment	Analysis
Anti-static film	OK	0.15mm 6"x8" soft PVC film	2.95	Recycle	These three layers protect the screen, it is not the simplest packaging and it is not cost effective.
Polybag	OK	360mmx450mm .02PE	0.45	Recycle	
Corrugated Wrapper	OK	175# B flute Single wall Kraft	5.17	Recycle	
Corrugated sheet insert	OK	15"x2 ½" 175# B flute Single wall Kraft	0.95	Recycle	Arm is the tough part and there is no movement inside of package, so sheet is not necessary
Styrene foam insert	OK	White EPS	10.50	Recycle	This part is over-packed from the mechanical protection view point
Styrene foam container	OK	White EPS	15.10	Recycle	
Shipper	Hard to open for end user	24 ½"x17 ¼"x8 ½" FOL 200#AB flute double wall Kraft	16.23	Recycle	Need to change shipper style to improve the convenience
Total			**51.35**		

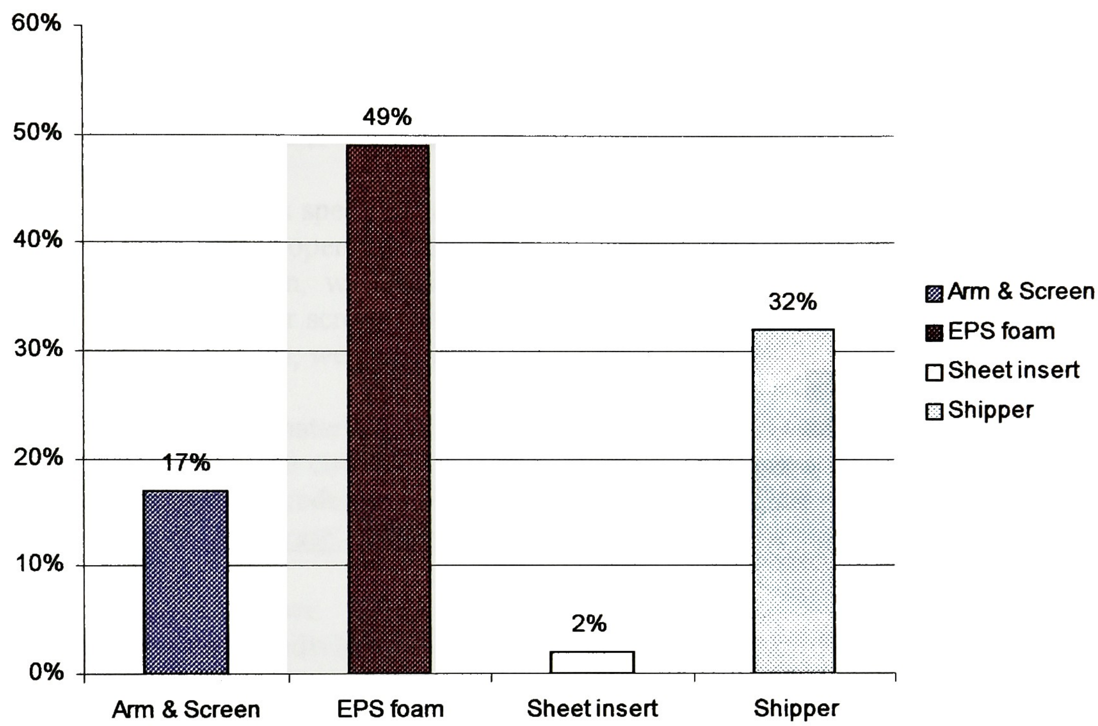
From the analysis above, some problems are recognized:

- Too many layers in screen packaging is not cost effective
- Corrugated sheet inserted between arms is not necessary
- Styrene foam insert and container is over-packed
- Shipping box style difficult to open is inconvenient to end users

6.1.3.1 Cost Analysis

We can clearly recognize from figure 5, Cost Distribution chart below, that the major cost is in the styrene foam insert and container. It is 49 % of the total cost.

Figure 5: The original package cost distribution



6.1.4 Critical Parts Need Improvement

From the cost deduction subject and the result of the analysis, three major packaging parts need improvement. One is a three-layer screen protection and the second is the foam EPS cushioning protection. The third part is the shipper, which needs to change its style to meet the user's requirement of being easy to open. In addition, the insert between the arms may be eliminated.

6.2 Redesign Process

6.2.1 Concept forming

This is a redesign project; the major objective here is cost reduction. The research is centered on the critical parts that need improvement in terms of cost effectiveness. The source of information needed for the research can be acquired from vendors, libraries or Internet and related academic sources.

From recommendations by the supplier, we reviewed the PVC pouch design sample and its test result, decided to use the PVC pouch instead of the polybag and corrugated wrapper.

From the Internet, the advanced packaging technology, foam-in-place packaging has been found that could be used in PC MagniViewer packaging to replace the styrene insert and styrene container. Further research should be conducted regarding environmental consideration.

From the corrugated box specification book, the RSC box will be chosen instead of FOL to solve the difficulty in opening problem by the end users.

During the investigation, we discovered the product's characteristics, especially, the fragility of the magnifier screen, distribution flow, warehousing information, cushioning materials, cost, etc. Then, we programmed these elements into data flowchart and table to assistant the redesign.

From the packaging material and packaging technology research, we found some solutions to improve the current PC MagniViewer package in terms of cost reduction. They are indicated the redesign of each part with applying the SyNalysis method and design procedure, **Integrate – individual--Parts – Details – Individual--Integrate.**

6.2.2 Redesign Procedure

6.2.2.1 Integrate and individual

In this PC magnifier example, this packaging system has already existed and worked okay. In general, there is no significant change in the packaging system besides the foam-in-place design option. It may have some minor changes that are caused by parts or detail changes. The orientation of the PC magnifier in the package may have some change in accordance to cushions change or some other changes. So, integrate and individual redesigns cannot be taken until the further research and parts & detail redesign are completed.

6.2.2.2 Parts and details

6.2.2.2.1 Magnifier screen packaging redesign

The original shortages:

- Three layers cost too much in manufacturing labor cost
- Very difficult to pack the wrapper
- It is not easy to open for user

Solutions:

The new screen package remains an anti-static thin film to provide protection against surface scratch and uses one PVC pouch instead of the plastic pouch and corrugated wrapper. There are several significant benefits from these design changes:

- Recover slight amount of packing space;
- Save packing material which leads to cost reduction

- Reduce package weight
- Simplify manufacturing process in term of saving labor
- Ease package opening operation for user

This new design eliminates all the shortcomings of original design in this regard and achieves the cost reduction goal without sacrificing the package function performance. Additionally, the new PVC pouch adds one new function as a bonus that it can be used as a cover to shield from dust when the computer is not in use.

6.2.2.2.2 Cushions Redesign

Cushioning material and its configuration are critical parts in the cushioning redesign. We should have fragility factor, drop height, static loading by collecting, estimating and calculating to start the redesign.

Statement:
PC MagniViewer's weight – 14lb,
1 person handling
Drop height – 30in
Insurance level -- II

Fragility Factor:
There are three possible ways of determining the fragility factor:

- By testing
- By calculation
- By estimation

Though theoretically possible, calculations are used only if we have enough mechanical and structural data of the object, which is usually not the case. Hence, in practice, this approach is only used on some very simple items. Since the PC MagniViewer is a complex product, it is difficult to calculate its fragility. Lab testing is also not used here because of the costs incurred by breaking an expensive PC MagniViewer.
Since the fragility is not a focal point in this thesis, an estimating method was used to obtain the fragility data of the PC magnifier. Using typical value, given in **table 3**, I estimate its fragility was about 80g's. The reason for this is that PC MagniViewer's fragility should be larger than a TV screen set because TV screens are made of glass, and the PC MagniViewer is made of acrylic which is a tougher material[3].

---

[3] Handbook of Packaging Engineering by Joseph F. Hanlon 1984

3: Typical product fragility factors[3]

Classification	Fragility	Type of product
Highly fragile	15 – 25g	Precision instruments with sensitive mechanical bearings
Very fragile	20 – 40g	Electro-mechanical measuring instruments
Fragile	40 – 60g	Electro-mechanical equipment. E.g. Type writing, cash registers, calculating machines etc.
Moderately fragile	60 – 85g	Television receivers, optical projectors
Fairly robust	85 – 100g	Domestic appliances (washing machines, refrigerators, cookers)

Calculation for cushion design:
If the new cushion design maintains the original cushioning material EPS, how much EPS material need in the package from shock and vibration theory?

PC MagniViewer:
W = 14lb
G = 80g'
H = 30"
Dimensions:
15" x 21" x 5 ¼"

Maximum dynamic compression Dm = 2h / gm = 2x30 / 80 = 0.75in
If the working length = 60%
Total thickness TT = dm /0.6 = 0.75 / 0.6 = 1.25in
We find psi is 0.4 from the EPS curve[4]

The bearing area of the cushioning = product weight / static loading
14lb /0.4psi = 35in^2

From the result of the calculation, we found that the PC MagiViewer needs at least 35in^{2}cushion in the package. Due to the product's two parts specific configuration, the cushioning function is to fix the screen and the arm from shifting around more than mechanical protection from shock & vibration. Fixing the Arm & Screen part on the Base part is critical when we consider the cushion redesign problem.

[4] Fundamentals of packaging dynamics page-133

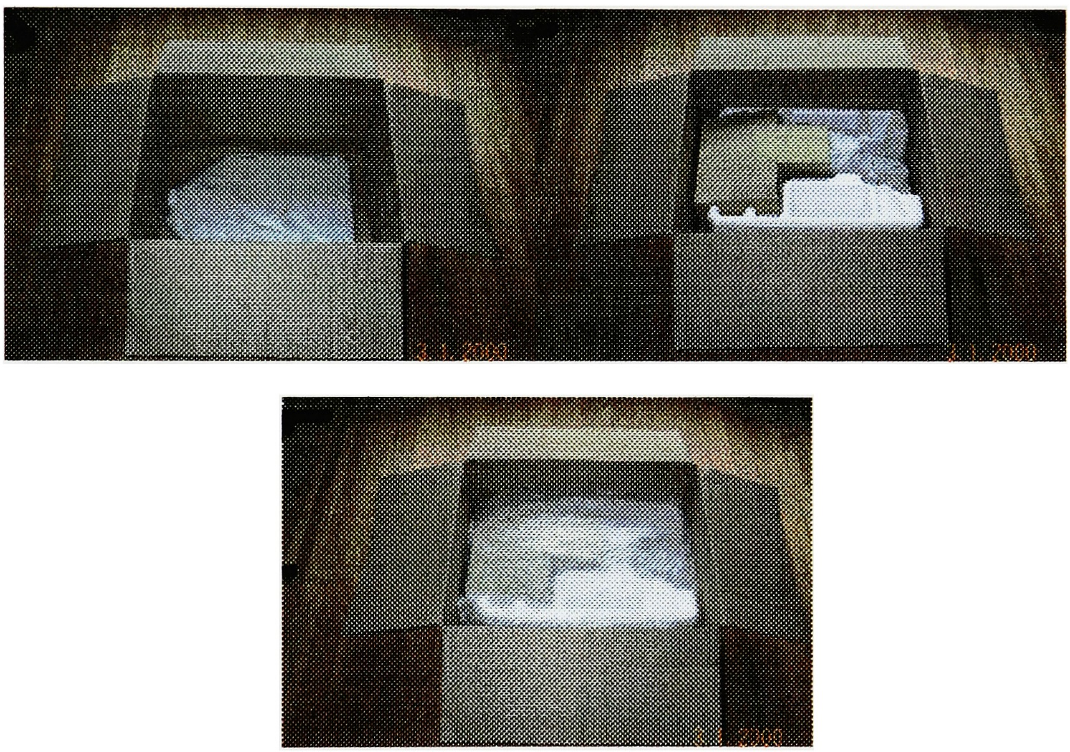
6.2.2.2.3 Redesign Possible Plan

We could go three basic possible redesign directions. One is retaining the same EPS material and reducing the cushion dimensions. Option I is the redesign. The other is changing the cushioning material and changing the packaging system that is the option II. The third one is changing the cushioning material that is the option III.

Option I

Eliminate the EPS foam container by adding two EPS sheets at the bottom and the top, and retain the EPS form insert (see figure 6)

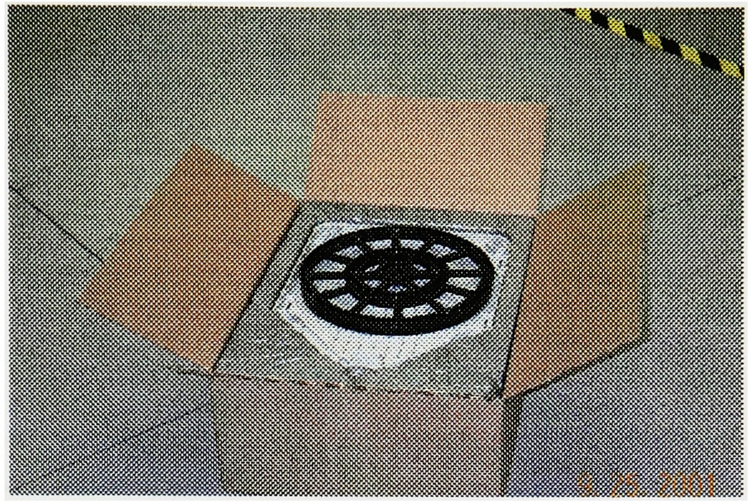
Figure 6: Option I,
Eliminate the EPS Container and use two EPS sheets at bottom & top



Option II

Use form-in-place hand-held packaging system to replace the EPS foam container and insert without change the shipper dimensions. (See figure 7)

Figure 7: Option II, Foam-in-Place:



Option III
Change the EPS cushioning material to corrugated board both on base and screen & arm parts, adding plastic bags on these two parts to avoid the dust. (See Fig. 8, 9, 10, 11, and 12)

Figure 8: Option III, Corrugated board cushioning

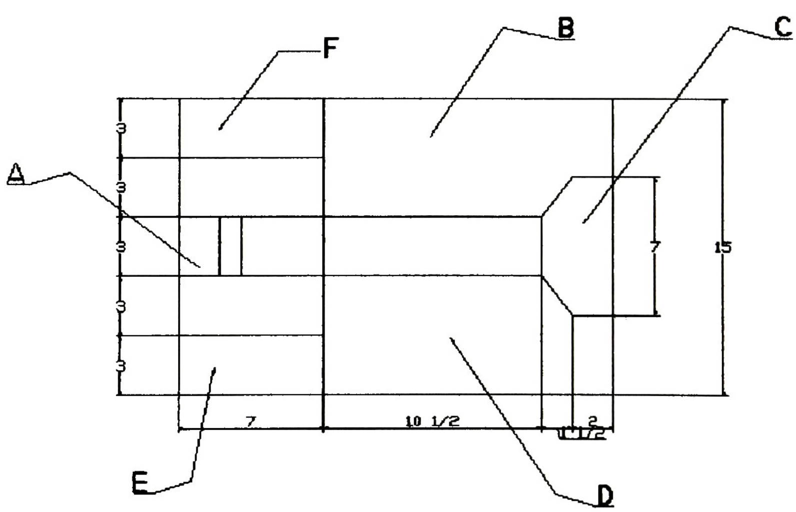


Figure 9: Option III, Base Wrapper

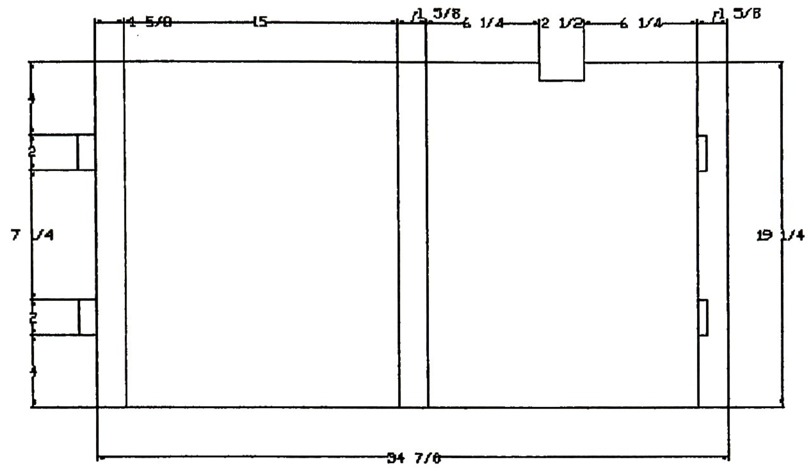


Figure 10: Option III, Detail A

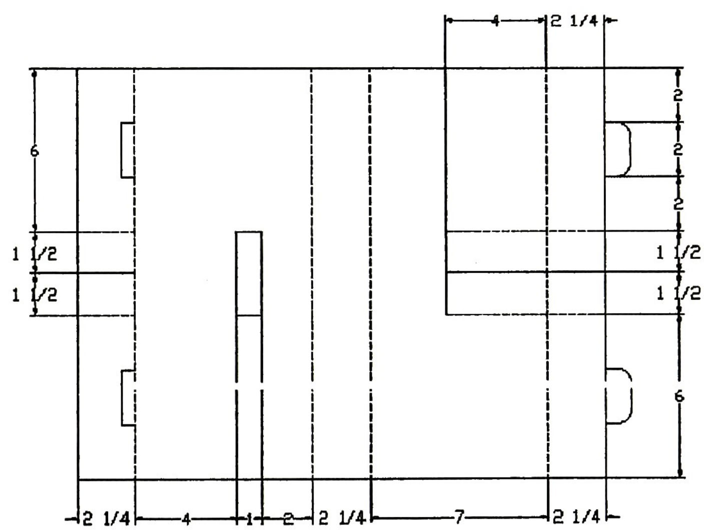
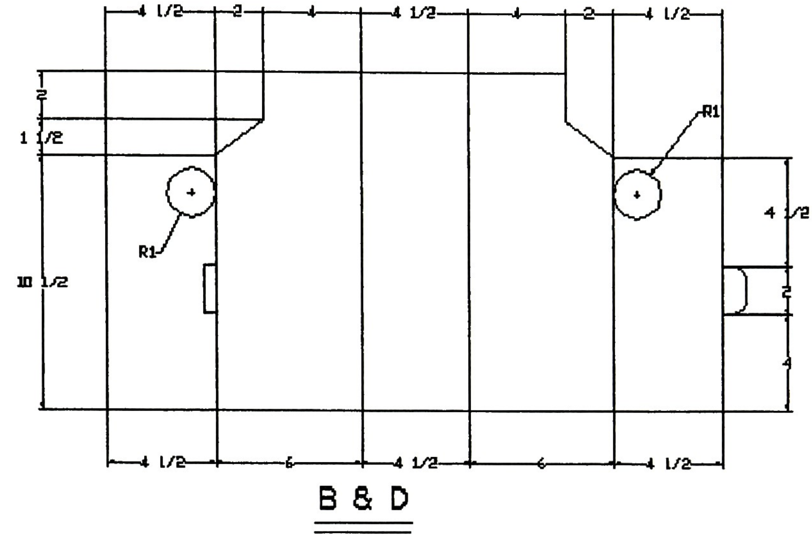
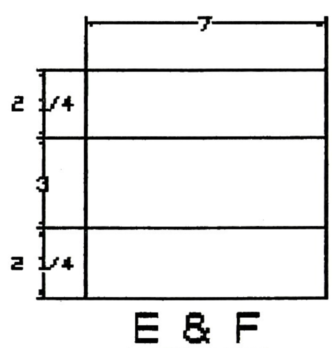


Figure 11: Option III, Detail B & D



Note: D section has two holes and B section has not.

Figure 12: Option III, Detail E, F & C



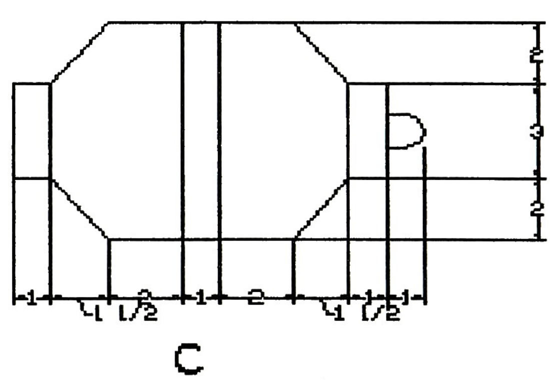
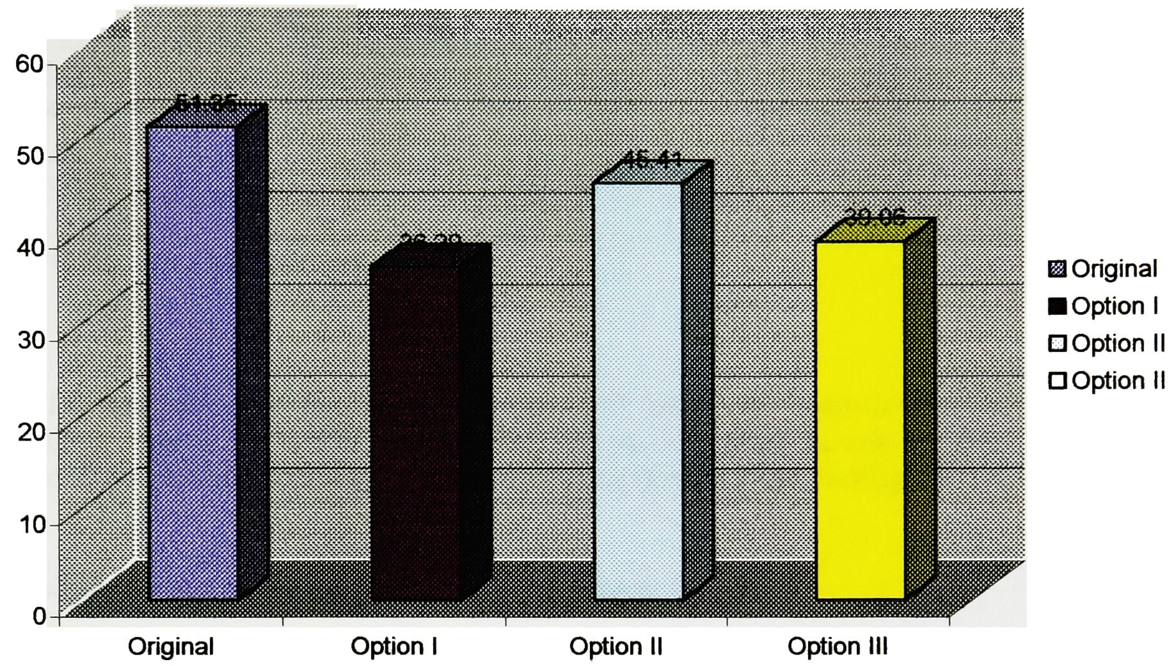


Figure 13: The packages cost comparison chart



6.2.2.2.4 The Three options Comparison

From the table 5 below, the least points is option II, foam-in-Place hand-held packaging system. Option I has the minimum changes from the original PC MagniViewer packaging with significant cost reduction, but its fragmentariness may influence the performance of the package and the packaging labor cost. Option III has the most changes but its complicated in packing process will increase the labor cost. The optimal redesign plan is the option II, Foam–In-Place hand- held packaging system. Because:

- Foam-in-Place can be created in a variety of sizes and shapes, it efficiently protects magnifier in size, shape and two parts movement difficulties
- Foam-in-Place has good cushioning protection to protect the product.
- Foam-in-Place packaging system simplifies the packaging production process
- Foam-in-place saves the foam-shipping trip from packaging supplier to production line.
- Foam-in-Place speeds up PC magniViewer's packaging process and significantly improves productivity
- Foam-in-Place has light weight and saves transportation cost
- Foam-in-Place saves labor cost

Table 4: Three Options Comparison Table

Packages / Evaluation	Original	Option I EPS Insert & Sheets	Option II Foam-In-Place	Option III Corrugated Board
Functions	OK	OK	OK	OK
Weight	3	2	1	4
Dimensions	3	2	4	1
Labor	3	2	1	4
Transportation	4	3	1	2
Cost	4	1	3	2
Environment	Recycle	Recycle	Possible Reuse	Recycle
Total points	18	11	8	13

* 1 is the least, 4 is the most

The PC MagniViewer packaging redesign will select the foam-in-Place hand-held packaging system, the rest of the work is focus on contacting the sale representative of Sealed Air packaging company to select right equipment and the package design.

6.2.2.3 Individual: New PC MagniViewer Package Design

The new package is made of three parts, Arm & screen packaging, the cushion, which is foam-in-place, and the shipper. Comparing with the original package, there is an obsolete corrugated insert part. (See figure 14)

Arm & Screen part:	Anti-static film in both side of the screen PVC pouch cover the Screen
Foam cushions:	Use Foam-in-Place instead the original EPS Insert and container Discussed with vendor, Instapak model 901 Foam-in-Place Hand-Held Molding System will be taken.
Type:	Top and Bottom Cushions
Process:	Molded-Hand Held Equipment
Foam Used:	Instapak 40
Foam Amount:	1.8 lb total
Film:	Instamate Film
Film Roll Width:	72”
Film Length:	54”

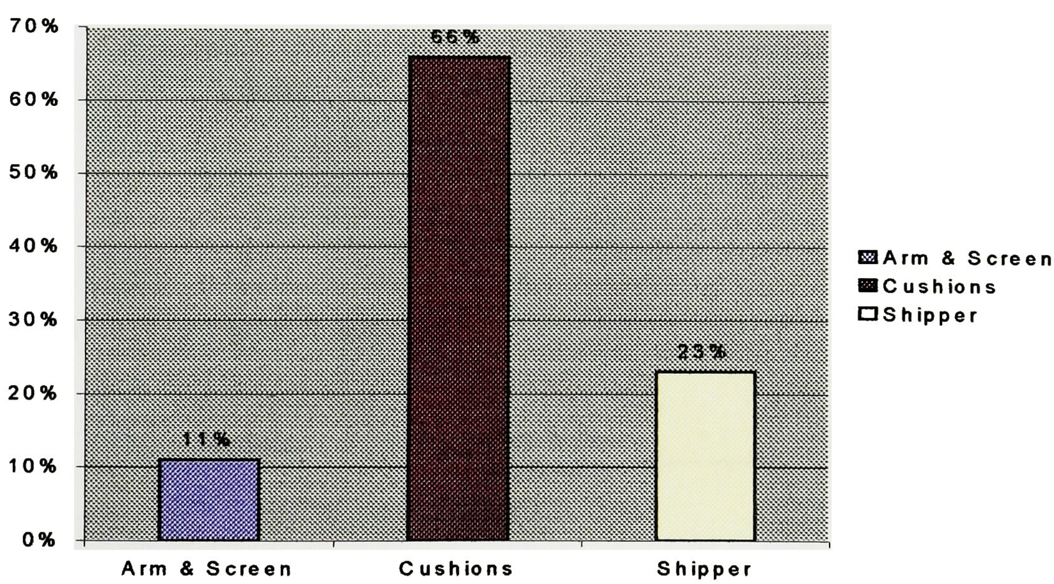
Container Style:	RSC
Container Strength:	275 Bursts
Container Walls:	Single Wall
Container Size:	24” x 18” x 9 3/8”

6.2.2.3.1 New PC Magnifier Package Cost

Arm & screen part	5.09 RMB
Instapck 901Foarm-in Place Packaging System	$5,000 (40,000 RMB)
A pair of chemical drums	$1,944.60
A roll of Instamate Film (13,200 feet^2)	$160
Instamate Film (72" x 54")	$ 0.328 (2.62 RMB)
Foam (1.8 x 1.9)	$ 3.4 (27.2 RMB)
Total cushioning cost	$ 3.73 (29.82 RMB)/package
Shipper 24" x 18"x 9 3/8" (61cm x 46cm x 24cm) 7.92 RMB / m^2 for single wall in Chinese packaging market	10.50 RMB
Total New Package Cost	**45.41 RMB**

The new package cost distribution is showed below in figure 14. The lowest cost is the Arm & Screen part, and the highest cost is the cushioning. This cost distribution is similar to the original package cost distribution. The largest cost component is the cushion which is 66% of the total.

Figure 14: New Package Cost Distribution Chart



6.2.2.4 Integrate: Packaging Process

The Instapak 901 Foam-in-Place packaging system will be installed on the end of the PC MagniViewer production line. Its packaging operation process is listed below:

1. A simple wood mold is used to produce the desired cushion shape.
2. Instamate film is placed into the mold and Instapak foam is dispensed.
3. Place the Arm & Screen part into custom-shaped foam cushions.
4. A second wood mold is used to produce the desired cushion shape.
5. Place the shaped cushion onto the Arm & Screen part.
6. Place the Base part into the second shaped cushion.
7. Close the shipping box and seal the box.

The new packaging system saves shipping EPS foam from the packaging vendor to the PC MagniViewer production line. In addition, it saves the inventory for the EPS foam as well. Figures15 & 16 below show the packaging processes and the trip and inventory process savings.

Figure 15: Original Packaging System

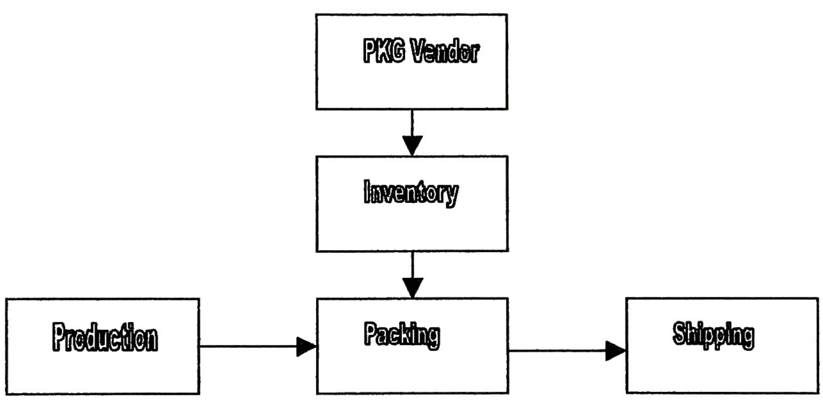
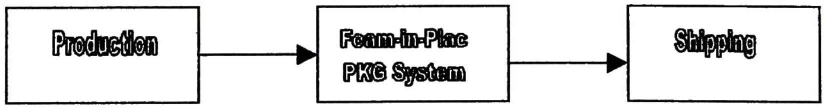


Figure 16: New Packaging System



6.3 Evaluating Process

The purpose of the single container test is to determine the ability of the individual container and its interior packaging to protect the product from transportation vibration, particularly when the container and its product might exhibit responses. The new foam-in- place sample package is tested in RIT packaging lab before we put it into the production.

6.3.1 Lab Test Method

The package test applies ASTM D 4169, DC-3 Standard Practice for Performance Testing of Shipping Containers and Systems or alternative method ISTA 3C Performance Test for Individual Packaged-Products 150 lb (68 kg) or less For Parcel Delivery System Shipment. Assurance Level – II, drop Height: 30", test sequence listed below:
Free Fall Drops
Compression
Fixed Displacement Vibration
Random Vibration
Free Fall Drop

6.3.2 Test Results

The test result showed that the new package works well and there was no any damage to the product inside the box. (See figure 17 to 19 below).

Figure 17: Corner and Edge Test Result

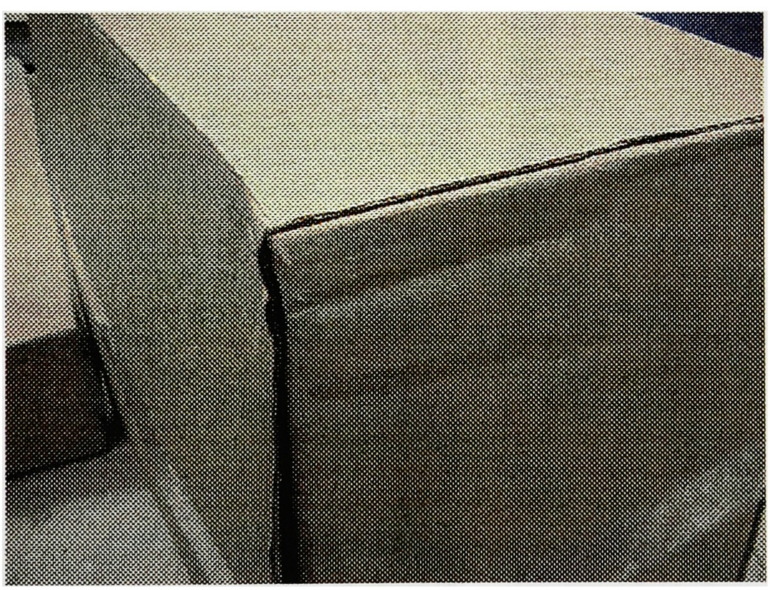
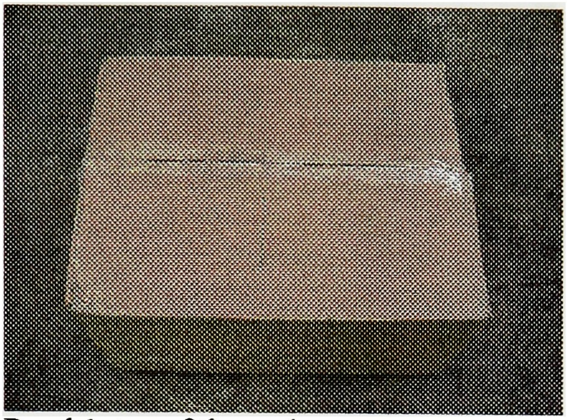
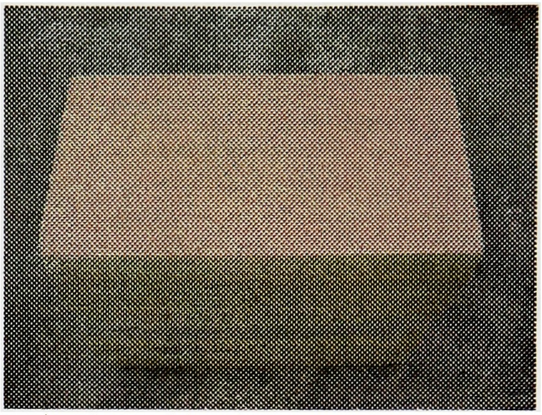


Figure 18: Outside of the Package Test Result

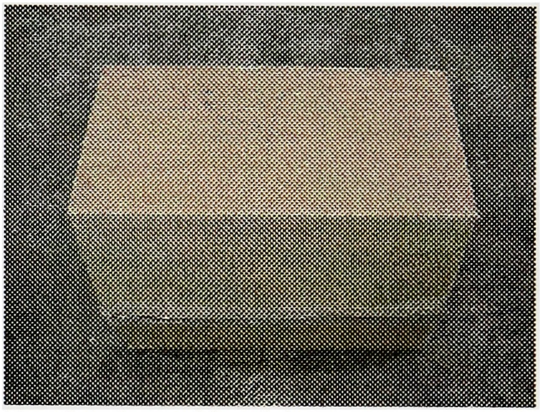


Panel 1: top of the package

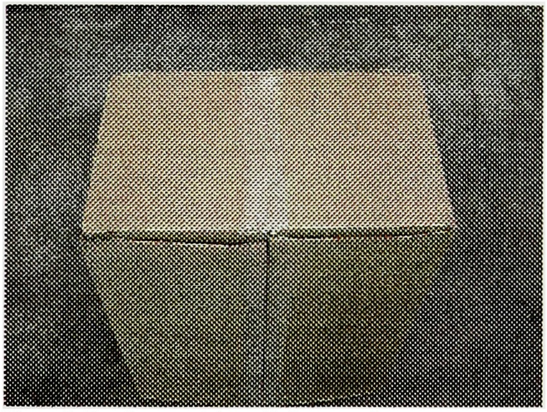


Panel 2: long side of the package

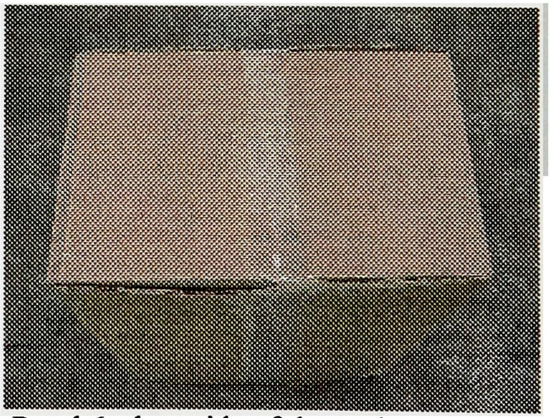
Panel 3: bottom of the package



Panel 4: long side of the package

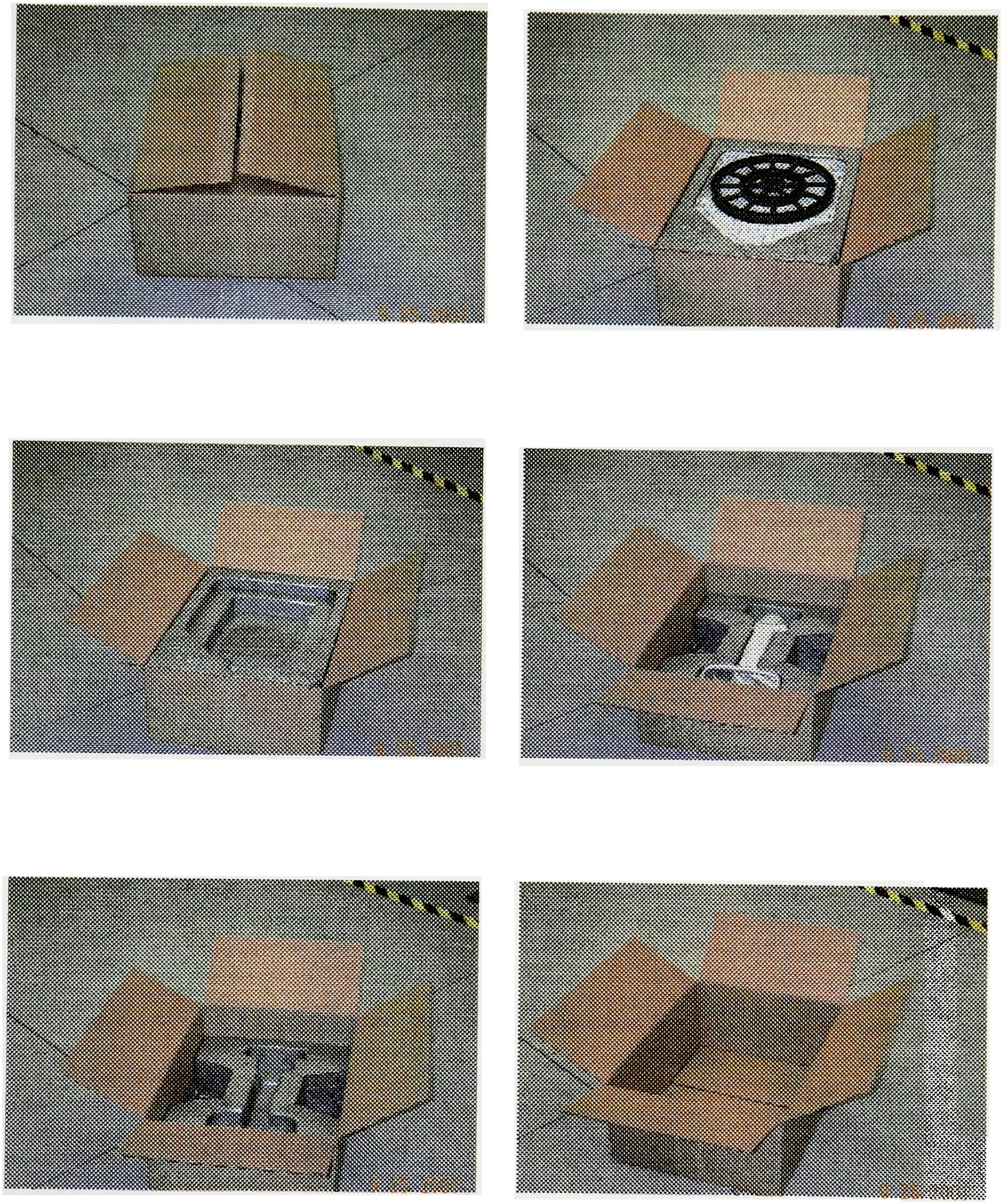


Panel 5: short side of the package



Panel 6: short side of the package

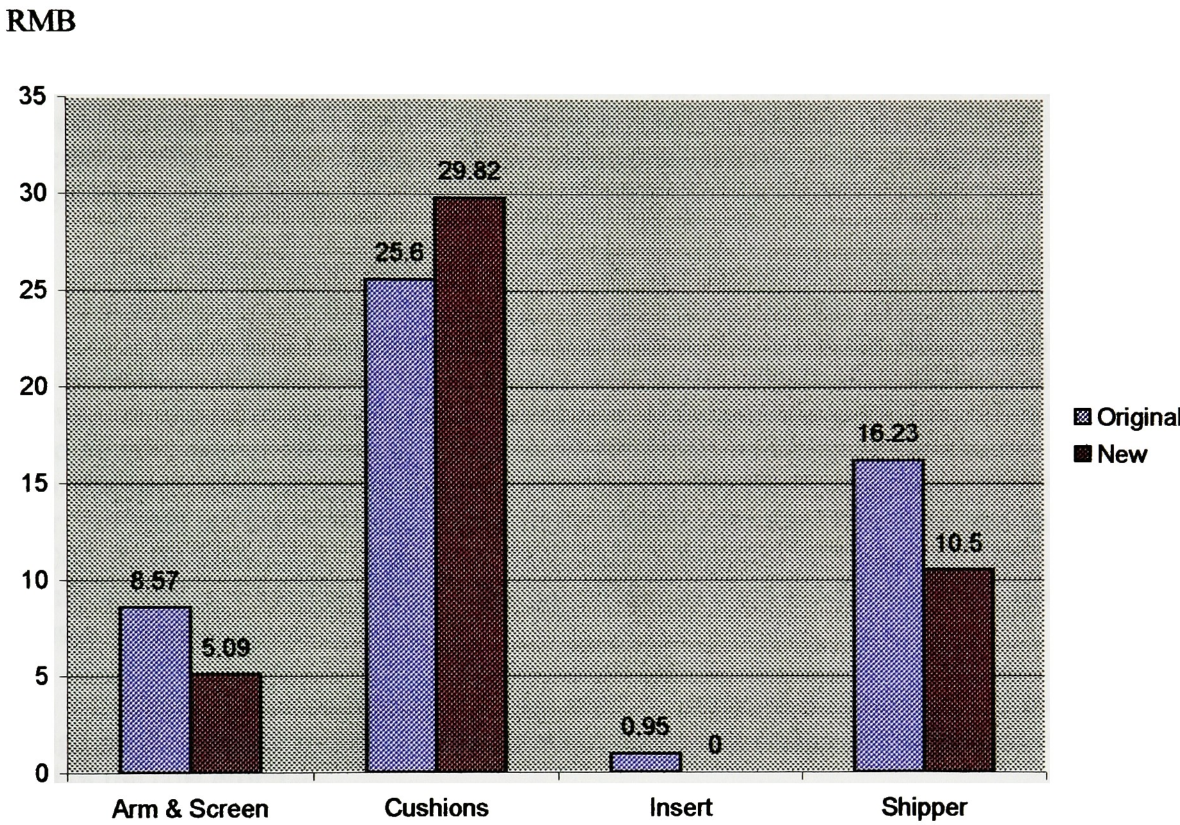
Figure 19: Inside of the Package Test Result



6.4 Cost Comparison

The original Arm & Screen part packaging costs 8.57 RMB and the new one is only 5.09 RMB. The EPS Foam costs 25.60, and the foam-in-place is 29.82 RMB. The insert part saving is 0.95 RMB. The original shipper spent 16.23 and the new shipper is only 10.50 RMB. (See Figure 20 below)

Figure 20: Cost Comparison Chart



From above Comparison chart, we recognized the savings for every part of the package:

Arm & Screen:	3.48 RMB
Cushions:	-4.22 RMB
Insert:	0.95 RMB
Shipper:	5.73 RMB
Total Saving:	**5.94 RMB**

The cost of original PC magnifier package is 51.35 RMB / each and the new redesigned package will be 45.41 RMB / each, so the total saving for each package will be 5.94 RMB. In addition, there is at least one trip saving for the foam shipping from packaging supplier to the production line, so the time and labor savings are extra.

6.5 Findings

From analyzing process, we found the screen packaging has too many layers that is not cost effective; the corrugated insert sheet between arms is not necessary; the styrene foam insert and the container is over-packed and the shipping box style is inconvenient to end users. The design directions were found from the concept forming process. Researching unknown elements and programming the known elements to emerge redesign ideas, the three cushioning design options were obtained quickly. Then comparing these options against packaging function, structure, cost and the requirements and limitations, choose the optimal design plan that is the best to meet all the requirements and cost the least.

Following the design procedure, Arm&Screen part redesign; cushions redesign and shipper redesign are well done by integrate-parts-detail-integrate steps. The evaluating process confirmed that foam-in-place packaging system is a practicable for PC MagniViewer packaging.

The new PC MagniViewer package reduces the cost compared to the original package. The total saving is 5.94 RMB for each PC MagniViewer package even though the foam part cost is higher than the original EPS, but the labor saving and the shipping trip saving should be counted to the packaging savings. Due to the complication of the labor saving calculation, the labor saving is not included in it. If the volume of PC Magnifier per year were 10,000, the saving would go up to 59,400 RMB annually. If we assume one trip from the packaging vendor to the production line is 500 RMB, and assuming 5 trips per year, the total savings would go up to 61,900 RMB annually. Therefore, we can return 40,000 RMB investment of the 901 hand-held equipment with 21,900 RMB savings within a year is a certain reality. This significant savings would definitely benefit for Bausch & Lomb's profit.

The PC MagniViewer packaging redesign practice proves that the SyNalysis packaging design method is one way to get the optimum packaging design or redesign to reach the goal of the cost efficient.

7.0 Conclusions

The SyNalysis packaging design method is based on the architectural building design methods. The reason for migrating the architectural design method to the packaging design is due to the four similarities in both building design and packaging design. The four similarities are design goal; design principal; thinking method and working style. The SyNalysis packaging design method combines scientific analysis, creative discovery and design synthesis methods. It contains analyzing, designing and evaluating three processes and the integrate-parts-detail-integrate design procedure, additionally, the creative concept forming process.

The analyzing process is very important because the designer can set up the right design direction and priorities through it. The concept forming process helps designers to widen their scope and grasp the emerging creative inspirations. Then following the direction and priorities, designers can find some concepts to go through the design procedure.

The integrate-part-detail-integrate design procedure is a step-by-step design process plus a step-by-step reverse checking up process. It helps designers to be on the right design track and the packaging design is an integrated design that has no conflict among parts. The evaluating process is a scientific testing process. It helps designers to obtain a reliable package before it is put into production.

The PC MagniViewer package redesign is an example to practice the SyNalysis packaging design method step by step. From analysis process, we clarified the known information and the design directions. After we research the unknown elements, we have all the required design elements. Programming these elements and following concept forming and the design process, we had design ideas and designed the possible design options. Starting from integrate packaging design consideration, we got three design options that probably meet the packaging system and the shipping circle. They are option I: eliminate the EPS foam container by adding two EPS sheets at the top and the bottom; option II: use foam-in-place hand-held packaging system to replace the EPS foam container and insert and the option III: Change the cushioning material from EPS to corrugated board. The optimal design plan was selected by using the comparison table, which is option II, foam-in-place. This part needs further research. The parts and detail design started right after the optimal design plan was decided. The last step of the packaging design was the integrate packaging system design with the new designed package. In this case, the integrate packaging design focused on production process design and the new packaging system savings in the shipping circle because there is no change in the rest of the packaging system. The evaluation process, lab test, proves that the new package could be put into the production.

The SyNalysis packaging design method is logical and practical through the PC MagniViewer practice. It helps designers to analyze information rationally and synthesize the information systematically into the design process. Its three processes, analyzing, designing and evaluating process make the design straight and clear. Following these three processes and the concept forming process, designers can have more design options effectively. Then through the comparison, the optimal packaging design can become a reality.

The comparison table in this research that I designed for selecting the optimal packaging redesign plan is simple, incomplete because many factors are not included. It may not be applicable for some complicated design plans. There are some disadvantages:

The factors, such as function and environment have not grade them because they are all ok include over-packed ones. How do we compare the functions among these packages? Same problem as environment, reuse is definite better than recycle and recycle is better than disposal? Therefore, the way to grade these factors scientifically and rationally is the key for selecting the best design plan.

The factors are not included completely in this comparison table; therefore, the result of the total points may not accurate or simply wrong in the complicated packaging design project specially.

Packaging system has not been considered in the comparison table of this research paper. In fact, the best package is the best in this packaging system may not be the best in that packaging system. So, the packaging system background should be one important factor to count into it.

Design is a synthetic process more than scientific process so, its right result would not be only one but there is an only one of the best result in a certain packaging system. It just like some other process or plan, there are some regularities to score every factor of the package and the relationship among these factors. There is some regularity to compare the design options just as some other process comparison. It is worth to do some research to find these regularities and to set up a mathematical formula by using optimization concept. Further, more, this mathematical formula can become computer software. When people input the data, the result will show up within seconds.

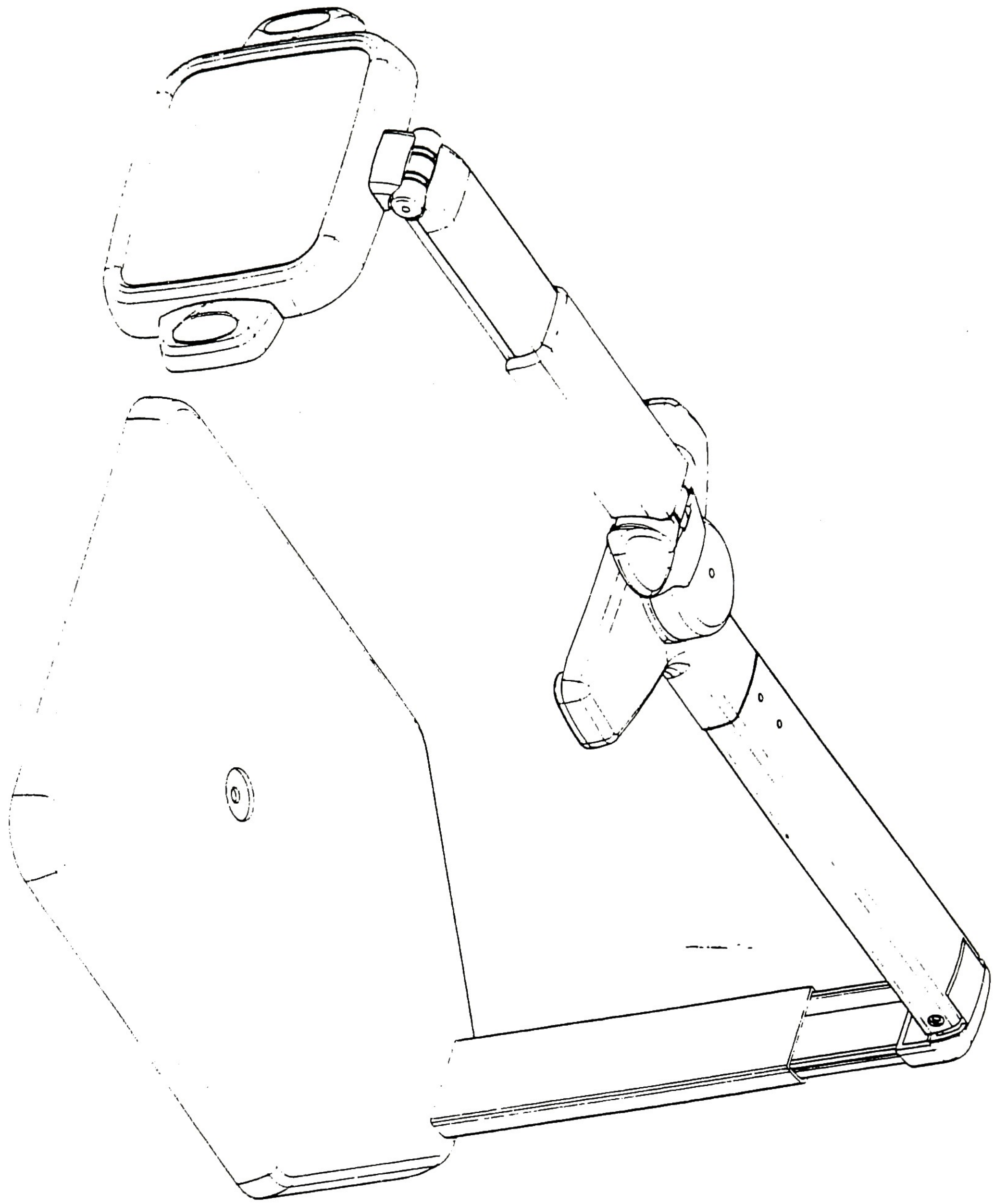
After this further research, user-friendly computer software of packaging comparison would be created to select the best package design and will let you know which one is the best for working in a certain packaging system.

The new PC Magni-Viewer from Bausch & Lomb magnifies and clarifies information on your screen

The PC Magni-Viewer is designed for computer users that have found themselves moving in, out, up or down from their monitor in an effort to see better. It can aid the millions of PC users who are constantly straining their eyes in an effort to focus on a screen that is a fixed distance away.

- Magnifies screen by 175%
- Multiple adjustments for better monitor viewing
- Ergonomically and visually correct solution meets individual sight and viewing distance requirements
- See more, and more clearly
  - increased rows and columns on spread sheets
  - more lines for word processing
  - more CAD/CAM information per screen

Appendix A-1: PC MagniViewer Specification



Appendix A-2: PC MagniViewer Figure

Sealed Air® Engineered Products Division

DESIGN DATA SHEET

Date	August 7, 2001	**Lab**	Canada & US North Atlantc
Sales Rep	Gary Tartick	**Designer**	Donald Nimphius

CUSTOMER \ PRODUCT

Request #	A-08082
Customer:	Bausch & Lomb
Address:	276 Ashbourne Rd. Rochester, NY. 14618
Contact:	Hanna Cao
Product:	PC Magnifier
Accessories:	
Notes:	

RECOMMENDED PACKAGE

Type:	Top and Bottom cushions	**Container Style**	RSC
Process	Molded-Hand Held Equipment	**Container Strength**	275 Burst
Foam Used:	Instapak 40	**Container Walls**	Single Wall
		Container Size I.D.:	24 x 18 x 9 3/8" inches I.D.
Foam Amount	1.8 lbs. Total		
Film:	Instamate Film		
Film Roll Width:	72"		
Film Amount:	54 Length		
		Enclosure Size:	

DESIGN NOTES

There was no testing due to a damaged product.

Appendix B: New Package Design Data

Hand-Held Molding Process

Thank you for the opportunity to design a Sample Package for your product.
If you have any questions feel free to call (203) 207-8831

希悦爾包裝(上海)有限公司
Sealed Air Packaging (Shanghai) Co., Ltd.

Date: April 19, 2002

To: Ms Cao Jun

From: Robert Zhang Huiqing of Sealed Air Shanghai

Re: Quotation of Foam-in-place Packaging System

As we discussed this afternoon (Beijing time), I am very pleased to fax you this quotation for you kind attention. All the prices quoted are CIF, Tianjin, duty free prices to be paid in U.S. dollars, subject to final confirmation. Installation, training and 6-month warranty is provided free of charge. Both parties shall work together for customs declaration and the charge, about RMB300, will be borne by the buyer. This quotation is valid for 30 days.

1.	901 hand-held system with a work station (no vacuum)	\$5,000
2.	Chemical A & B in 55-gallon drums (total 463kgs/pair)	\$4.2/kg
3.	36" gray film	\$160/roll

Should you have any more inquiry please contact me.

Looking forward to hearing from you soon.

Sincerely yours,

Northern China Representative

中國上海市外高橋保稅區富特北路227號底層　郵編: 200131　電話 TEL: (021) 5866 2813, 5866 3003　傳真 FAX: (021) 5866 2306
G/F, NO.227, FU TE NORTH ROAD, WAIGAOQIAO FREE TRADE ZONE, SHANGHAI, CHINA, 200131 TEL (021) 5866 2813, 5866 3003 FAX: (021) 5866 2306
辦事處: 上海黃陂北路227號中區廣場701A室　郵編: 200003　電話TEL: (021) 6375 8769　傳真FAX: (021) 6375 8770
SUITE 701A, CENTRAL PLAZA, NO 227, HUANG PI NORTH ROAD, SHANGHAI, CHINA, 200003 TEL: (021) 6375 8769 FAX: (021) 6375 8770

Instapak® 901

Foam-in-Place Packaging System

All-Electric, Self-Diagnostic Controls, Built-in Timers and Much More.

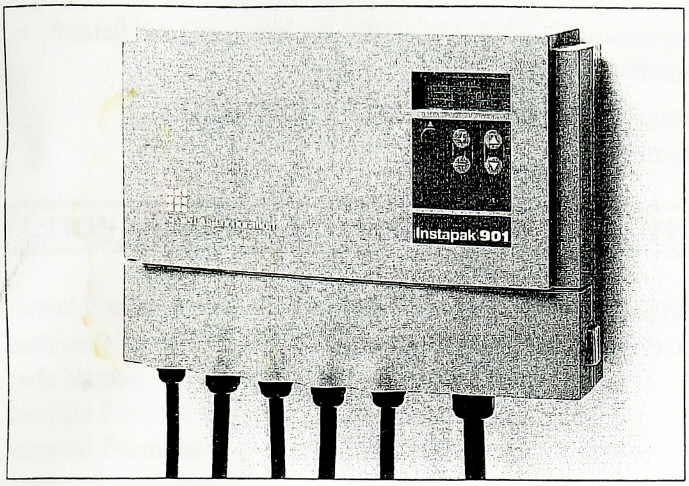
Workstation and Instapak® chemical containers not included.

Appendix D-1:Foam-in-Place Packaging System Information

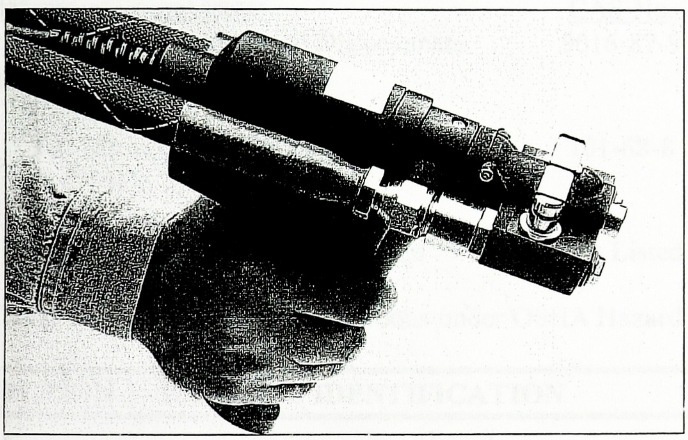
Sealed Air Corporation

Model 901

The All New Instapak® 901 Foam-in-Place Packaging System



Foam output controls, built-in timers and self-diagnostic features continually monitor system performance. All information is reported on the console's easy-to-read message center.



The Instapak® 901 system features a patented, self-cleaning cartridge dispenser that delivers high quality Instapak® foam.

The Most Advanced Hand-Held Foam Dispensing System Ever

•Economical

Built-in timers let you control the amount of material used. A series of ten dispense times can be used to simplify your packaging process.

•Flexible

The Instapak® 901 system can be adjusted to dispense foam at the ideal rate for your application.

- Instapak® 901 foam output rate 5 to 7.5 lbs/min.

•Safe

The 901 system meets major international product safety standards.

UL C UL LISTED PACKAGING SYSTEMS 4D53 E 167535

•Reliable

The electric pumps and self-diagnostic controls guarantee top quality Instapak® foam.

•Simple

The all-electric Instapak® 901 system installs in minutes. No scheduled maintenance is required.

Sealed Air® Support Services

- Operator training
- Equipment installation
- Package design and testing
- Site selection assistance

Utility Requirements

Electrical Power:	30 AMP, 208-240 Volt A.C., 50/60 Hz single phase dedicated circuit
Receptacle Type:	NEMA L6-30R

For important operating and safety information, please see the "Recommendations for the Safe Use and Handling of Instapak® Foam-in-Place Chemicals" bulletin.

Distributed by:

Appendix D-2: Foam-in-Place Packaging System Information

Sealed Air Corporation

Engineered Products Division

10 Old Sherman Tnpk., Danbury, CT 06810
(203) 791-3500 Fax: (203) 791-3618
www.sealedaircorp.com

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D-81 Rev. 6/98

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MATERIAL SAFETY DATA SHEET

EMERGENCY NUMBERS:

Sealed Air Corporation: (203) 791-3500 *For emergency and general information*
8:30am-5:00pm, (Eastern Time), Monday-Friday

CHEMTREC: (800) 424-9300 *For Chemical Emergency - spill, leak, fire, exposure or accident*
24 hours

SECTION 1 - PRODUCT AND COMPANY IDENTIFICATION

Product Name:	INSTAPAK® COMPONENT "A"
Chemical Name:	Polymethylene Polyphenylisocyanate
Trade Name:	Polymeric MDI
Chemical Family:	Aromatic Isocyanates
Chemical Formula:	Not Available

SECTION 2 - COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Components:	CAS No.	Wt.%	OSHA-PEL	ACGIH-TLV
Polymeric Diphenylmethane Diisocyanate (polymeric MDI or PMDI)	9016-87-9	100	Not Listed	Not Listed
Contains:				
4,4'-Diphenylmethane diisocyanate (4,4'-MDI; approx. 45%)	101-68-8		0.02 ppm (Ceiling)	0.005 ppm (TWA)
Other MDI isomers and oligomers	Not Listed		Not Listed	Not Listed

This product is classified as hazardous under OSHA Hazard Communication Standard (29 CFR 1910.1200).

SECTION 3 - HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Health Hazards: Irritating to eyes, respiratory system and skin. Inhalation at levels above the occupational exposure limit could cause respiratory sensitization and risk of serious damage to respiratory system. The onset of the respiratory symptoms may be delayed for several hours after exposure. A hyper-reactive response to even minimal concentrations of MDI may develop in sensitized persons. Sensitized persons should not be exposed to any mixture containing unreacted MDI.

Physical Hazards: Reacts slowly with water to produce carbon dioxide that may rupture closed containers. This reaction accelerates at higher temperatures.

Appearance: Dark brown liquid.

Odor: Slightly aromatic (musty).

Note: Read the entire MSDS for a more thorough evaluation of the hazard information on this product.

SECTION 4 - FIRST AID MEASURES

Inhalation: Remove patient from further exposure and obtain medical attention. Treatment is symptomatic for primary irritation or difficulty in breathing. If breathing is labored, qualified personnel should administer oxygen. Apply artificial respiration if breathing has ceased or shows signs of failing. Asthmatic-like symptoms, if manifested, may develop immediately, or be delayed for up to several hours.

Skin Contact: Remove contaminated clothing. Immediately wash affected area thoroughly with soap and water. Some organic materials such as corn oil or propylene glycol are effective in decontaminating MDI from the skin when applied immediately. Contaminated clothing should be thoroughly cleaned before reuse. If irritation, redness, or a burning sensation develops and persists, obtain medical advice.

Eye Contact: Immediately flush eyes with copious amounts of water for a minimum of 15 minutes, holding lids open with fingers. If irritation persists, repeat flushing. Refer individual to a physician for immediate follow-up.

Ingestion: Do NOT induce vomiting. Provided the patient is conscious, wash mouth out with water then give 1 or 2 glasses of water to drink. Refer person to medical personnel for immediate attention.

Note to Physicians: Symptomatic and supportive therapy as needed. Following severe exposure medical follow-up should be monitored for 48 hours.

SECTION 5 – FIRE FIGHTING MEASURES

Flash Point: 390°F (199°C) [Pensky-Martens Closed Cup]
Flammable Limits (lower): Not available
Flammable Limits (upper): Not available

Extinguishing Media: Water, carbon dioxide (CO_2), dry chemical, or appropriate foam. If water is used, large quantities are required. Reaction between water and hot isocyanate may be vigorous. Contain run-off water with temporary barriers.

Fire Fighting Procedures: As appropriate for surrounding materials/equipment.

Fire and Explosion Hazards: Containers may burst under intense heat. Due to reaction with water, a hazardous build-up of pressure could result if contaminated containers are re-sealed.

Fire Fighting Protective Equipment: Firefighters must wear self-contained breathing apparatus and full protective clothing (Bunker gear).

NFPA Hazard Code:		
	Health:	2
	Flammability:	1
	Reactivity:	1
	Special Hazard:	None

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SECTION 6 - ACCIDENTAL RELEASE MEASURES

Evacuate area surrounding the spill and prevent further leakage, spillage or entry into drains. Eye and skin protection should be worn during spill cleanup and ventilation maintained. If the potential for airborne concentrations of MDI above the PEL exists, then respiratory protection should be worn. Contain and cover spill with loose absorbent (earth, sand, sawdust or other absorbent material), or absorbent pillows, pads or socks. Collect absorbed material in open containers or plastic bags, and treat with deactivating solution (90% water, 8% concentrated ammonia, 2% detergent). Allow to stand uncovered for 48-72 hours to permit carbon dioxide to escape and solidification to occur. Wash spill area with deactivating solution and let stand for 15 minutes or longer. Dispose of spilled material properly.

SECTION 7 - HANDLING AND STORAGE

Storage Temperature: Min. 50°F (10°C) Max. 100°F (38°C)

Average Shelf Life: 12 months (when stored in original, unopened, sealed containers).

Special Sensitivity: Reacts with moisture to produce carbon dioxide gas.

Precautions to be Taken in Handling and Storage: Do not store product containers uncovered outdoors. Do not reseal containers unless it is certain that no moisture contamination has occurred. Do not breathe vapors or allow skin contact.

SECTION 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits:	OSHA-PEL:	4,4'-Diphenylmethane diisocyanate;	Ceiling = 0.02 ppm
	ACGIH-TLV:	4,4'-Diphenylmethane diisocyanate;	TWA = 0.005 ppm

HMIS Hazard Code:	Health	2*	Reactivity	1
	Flammability	1	PPE	B (Personal Protective Equipment)

*indicates a chronic hazard

Respiratory Protection: Due to the low vapor pressure of this material, the PEL is not likely to be exceeded under normal conditions. If the material is heated or spilled in a confined area, respiratory protection should be worn. An approved air purifying respirator equipped with an organic vapor cartridge and a HEPA (P100) particulate filter may be used when an appropriate cartridge change-out schedule has been developed in accordance with the OSHA respiratory protection standard (29 CFR 1910.134). Where concentrations exceed the level for which an air-purifying respirator is effective, use a positive pressure, supplied air respirator.

Eye Protection: Safety glasses with side shields or goggles.

Protective Clothing: Chemical resistant butyl rubber, nitrile rubber, neoprene, or other suitable protective gloves.

Ventilation: Use local exhaust ventilation if necessary to maintain levels below the PEL. For guidance on engineering controls refer to the ACGIH publication "Industrial Ventilation."

Other: Eyewash station, safety shower and deactivating solution should be available. Refer to the "Recommendations for the Safe Use and Handling of Instapak® Foam-in-Place Chemicals" bulletin before handling Instapak® chemicals.

SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES

Physical State: Liquid
Color: Dark brown
Odor: Slightly aromatic (musty)
Vapor Density (Air = 1): 8.5
Molecular Weight: Approx. 350
Melting Point: Not established.

Boiling Point: 406°F (208°C)
Vapor Pressure: < 10^{-5} mm Hg at 25°C (for Polymeric MDI)
Specific Gravity: 1.24 at 25°C
Bulk Density: 10.3 lbs/gal
% Volatile by Volume: Nil
Solubility in Water: Not soluble. Reacts slowly with water to liberate CO_2 gas.

SECTION 10 - STABILITY AND REACTIVITY

Stability: Stable under normal conditions. Avoid temperatures above 110°F (43°C) or below 40°F (4°C).

Polymerization: May occur at elevated temperatures in the presence of moisture, alkalies, tertiary amines and metal compounds.

Conditions to Avoid: Contact with moisture and other materials that contain active hydrogen.

Incompatible Materials: Water, amines, strong bases and alcohols. The reaction with water is slow at temperatures less than 120°F (49°C) but is accelerated at higher temperatures.

Hazardous Decomposition Products: Highly unlikely under normal industrial use. Exposure to fire or extreme heat may generate oxides of carbon, oxides of nitrogen, and traces of hydrogen cyanide.

SECTION 11 - TOXICOLOGICAL INFORMATION

Polymeric MDI:	LD_{50} Oral:	>15,800 mg/kg (rat)
	LD_{50} Dermal:	>5000 mg/kg (rabbit)
	LC_{50} Inhalation:	370 - 490 mg/m^3/4 hours (rat) for an aerosol of polymeric MDI

Primary Route(s) of Exposure: Skin contact from liquid. Inhalation. However, due to the low vapor pressure, overexposure is not expected under normal conditions unless material is heated or used in a poorly ventilated area.

Inhalation: This product is a respiratory irritant and potential respiratory sensitizer. Inhalation of vapor or aerosol at levels above the occupational exposure limit can cause respiratory sensitization. Symptoms may include irritation to the eyes, nose, throat, and lungs, possibly combined with dryness of the throat, tightness of chest and difficulty in breathing. The onset of respiratory symptoms may be delayed for several hours after exposure. A hyper-reactive response to even minimal concentrations of MDI may develop in sensitized persons. Sensitized persons should be removed from any further exposure. Persons with asthma-type conditions or other chronic respiratory diseases should be excluded from working with MDI. In a single evaluation of 5 men occupationally exposed to MDI and hydrocarbon solvent vapors under conditions where adequate ventilation or other safety precautions were not used, neuropsychologic findings were attributed to MDI.

Skin Contact: May cause irritation or rash. Can cause skin discoloration. Repeated and/or prolonged contact may result in skin sensitization. There is limited evidence from laboratory tests that skin contact may play a role in respiratory sensitization. This data reinforces the need to prevent direct skin contact and the importance of protective gloves.

SECTION 11 - TOXICOLOGICAL INFORMATION (continued)

Eye Contact: Liquid can cause eye irritation, tearing, reddening and swelling. Permanent corneal injury is unlikely. Exposure to MDI vapors in excess of 0.02 ppm may cause irritation.

Ingestion: Ingestion is unlikely. Based on the acute oral LD_{50}, this product is considered practically non-toxic by ingestion. Ingestion can cause irritation and corrosive action in the mouth, stomach and digestive tract.

Chronic Effects: A study was conducted where groups of rats were exposed for 6 hours/day, 5 days/week for a lifetime to atmospheres of respirable polymeric MDI aerosol either at concentrations of 0, 0.2, 1, or 6 mg/m^3 (which corresponds to MDI levels equal to the OSHA-PEL, 5 times the OSHA-PEL and 30 times the OSHA-PEL). No adverse effects were observed at 0.2 mg/m^3 concentrations. At the 1 mg/m^3 concentration, minimal nasal and lung irritant effects were seen. Only at the top concentration (6 mg/m^3) was there an increased incidence of benign tumor of the lung (adenoma) and one malignant tumor (adenocarcinoma). MDI administration to rats in this study did not change the distribution and incidence of tumors from those seen in control animals. The increased incidence of lung tumors is associated with prolonged respiratory irritation and the concurrent accumulation of yellow material in the lung. In the absence of prolonged exposure to high concentrations leading to chronic irritation and lung damage, it is highly unlikely that tumor formation will occur.

Carcinogenicity: The ingredients of this product (>0.1%) are not classified as carcinogenic by ACGIH or IARC, not regulated as carcinogens by OSHA and not listed as carcinogens by NTP.

Mutagenicity: There is no substantial evidence of mutagenic potential.

Reproductive Effects: No adverse reproductive effects are anticipated.

Teratogenicity and Fetotoxicity: No birth defects were seen in two independent animal (rat) studies. Fetotoxicity was observed at doses that were extremely toxic (including lethal) to the mother. The dose that produced this effect (1.2 ppm) is 60 times higher than the OSHA-PEL. Fetotoxicity was not observed at doses that were not maternally toxic. The doses used in these studies were maximal, respirable concentrations well in excess of the defined occupational exposure limits.

SECTION 12 - ECOLOGICAL INFORMATION

Environmental Fate and Distribution: It is unlikely that significant environmental exposure in the air or water will arise, based on consideration of the production and use of the substance.

Persistence and Degradation: Immiscible with water, but will react with water to produce carbon dioxide, and inert and non-biodegradable solids.

Aquatic Toxicity:

LC_{50}:	>1000 mg/l (Zebra fish) At the highest level of 1000 mg/l, there were no deaths.
EC_{50} (24 hour):	>1000 mg/l (Daphnea magna)
EC_{50}:	>100 mg/l (E. Coli)

SECTION 13 - DISPOSAL CONSIDERATIONS

Incinerate or dispose of in accordance with existing federal, state and local environmental control regulations. This material is not a hazardous waste under RCRA 40 CFR 261 when disposed of in its purchased form. Small quantities should be treated with deactivation solution outlined in Section 6. Refer to the "Recommendations for the Safe Use and Handling of Instapak® Foam-in-Place Chemicals" bulletin for additional information concerning disposal of wastes and empty containers. Chemical waste, regardless of quantity, should never be poured into drains, sewers or waterways.

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SECTION 14 - TRANSPORT INFORMATION

DOT: Single containers less than 5,000 pounds are not regulated.

IMO: Not regulated.

IATA/ICAO Class: Not regulated.

Reportable Quantity (RQ): 5,000 lbs. for Methylene diphenyl diisocyanate (4,4'-MDI), CAS #101-68-8 (≈ 45% of product).

SECTION 15 - REGULATORY INFORMATION

TSCA Status: All ingredients are listed or are not required to be listed.

CERCLA Status: Discarded product is not a hazardous waste under RCRA, 40 CFR 261, when disposed of in its purchased form.

SARA 302 Extremely Hazardous Substances: None

SARA 311/312 Hazard Categories: Immediate (acute) Health Hazard
Delayed (chronic) Health Hazard

SARA 313 Listed Ingredients: This product contains the following chemicals subject to reporting requirements: 100% Diisocyanate compounds (Category Code N120).

SECTION 16 - OTHER INFORMATION

The following states have regulations that apply to the use of this product.

MA	Massachusetts Hazardous Substance List	NJ	New Jersey Hazardous Substance List
PA	Pennsylvania Hazardous Substance List		

The appropriate state agency should be contacted for further details on regulatory requirements for the substances shown below.

Ingredient	CAS No.	Wt. %
Methylene bisphenyl isocyanate (4,4'-MDI) (Benzene, 1,1'-methylenebis[4-]isocyanato-)	101-68-8	45

Section(s) Revised: Each section should be reviewed for possible revisions. New information on respiratory protection and HMIS Hazard Code ratings can be found in Section 8-Exposure Controls/Personal Protection.

Printed on recycled paper (50% secondary material, minimum 10% post consumer) using vegetable based inks. M-3 Rev. 10/00

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